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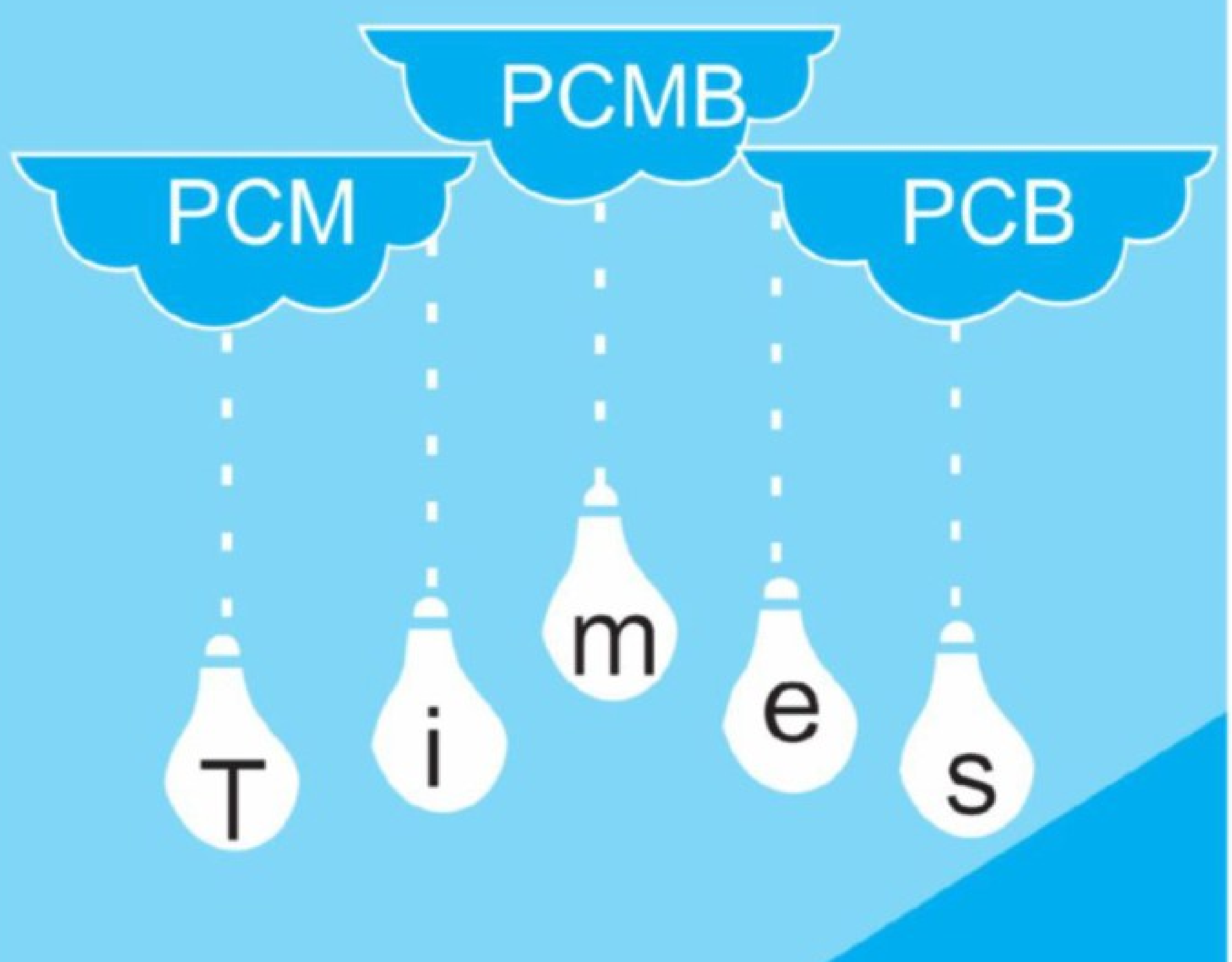
OCTOBER 2019

CHEMISTRY TIMES

SRI ABHAY PUBLICATIONS

VOL-V



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Eswar Reddy Alla, From Flat No:310, Fort House Apartment,
Balaji Layout, Kodigehalli, Bangalore-560092
PRINTED AT:
JAYAM PRINT SOLUTION, S.NO: 77/A, New Raja Rajeswaripet, Ajith Singh Nagar,
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Molecular Orbital Theory

Concept of the month

This column is aimed at preparing students for all competitive exams like JEE, NEET, BITSAT etc. Every concept has been designed by highly qualified faculty to cater to the needs of the students by discussing the most complicated and confusing concepts in Chemistry.

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Introduction

1. (a) Molecular Orbital Theory (M.O.T)

(i) The molecular orbital theory was put foreward by R.S Mulliken (1932) and F. Hund and it was later developed by I.E. Lennard Jones and charles coulson, which explains the bonding characteristics in a better way.

(ii)The MOT considers the entire molecule as a unit with all the electrons moving under the influence of all the nuclei present in the molecule.

(iii)This approach recognizes that each electron belongs to the molecule as a whole and may move within the entire molecule.

(b) Comparision between V.B.T and M.O.T

V.B.T

i. According to V.B.T electrons moves around only one nucleus

ii. Identity of atom retained

iii. According to V.B.T, O_2 is a diamagnetic

iv. Resonance play important role in this Theory

M.O.T

i. According to M.O.T electron moves under the influence of two or more nuclei

ii. Identity of atom lost

iii.According to M.O.T, O_2 is Paramagnetic

iv. Resonance has no role in this theory.

(2) Molecular orbitals

I. when the atoms to be bonded come close together, the orbitals of the bonded atoms lose their individual character. And fuse (overlap) to form larger orbitals called molecular orbitals.

II. Like atomic orbitals in an atom, there are molecular orbitals in a molecule.

III. The only difference is that in atomic orbitals, electrons move under the influence of only one nucleus (i.e, AOs are monocentric), while in molecular orbitals, electrons move under the influence of many nuclei (i.e., MOs are polycentric).

IV. Molecular orbitals may, therefore be defined as"the regions in space associated with all the nuclei of the molecule where the probability of finding a particular electron is maximum.

V. It may be noted that electrons in MO are not confined to an individual atom. They belong to the entire molecule and are said to be delocalized with respect to the individual atoms.

(3) Important features of M.O.T

i. Like an A.O (atomic orbital) which is around the nucleus of an atom there are M.O (Molecular Orbital) which are around the nuclei of a molecule.

ii. The molecular orbitals are entirely different from the atomic orbitals from which they are formed.

iii. The molecular orbital possess different energy levels like atomic orbitals in an isolated atom.

iv. The shape of molecular orbitals are dependent upon the shapes of atomic orbitals from which they are formed.

v. Molecular orbitals are arranged in order of increasing energy just like atomic orbitals.
vi. The number of molecular orbitals formed is equal to the number of atomic orbitals combining in bond formation.
vii. Like atomic orbitals, the filling of electron in molecular orbitals is governed by three principles such as aufbau principle, Hund's rule and pauli's exclusion principle.

(4) Conditions for atomic orbital (AO) to form molecular orbital (MO)

i. The combining A.O's should be of a comparable energy.
ii. The combining atomic orbitals must overlap to a large extent.
iii. greater the overlap, stable is the molecule formed.

(5) Difference between AO and MO

Atomic orbital (AO)

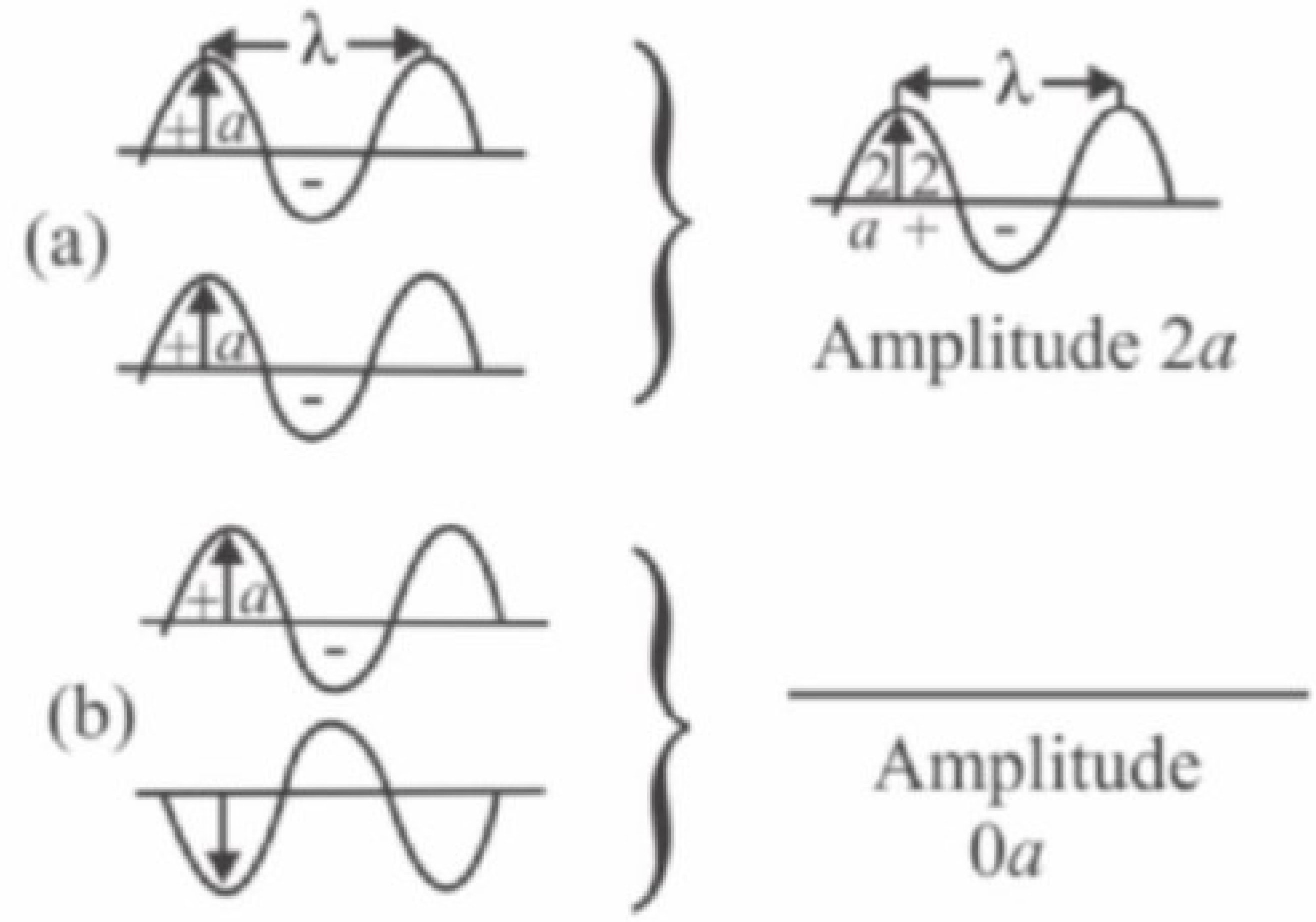
i. An electron in an A.O. is under the influence of only one nucleus
ii. They are monocentric.
iii. Their existence is because of inherent property of the atoms.
iv. They are less stable than bonding M.O. but more stable than antibonding M.O.
v. They have simple shapes
vi. They are represented by s,p,d,f.

Molecular orbital (MO)

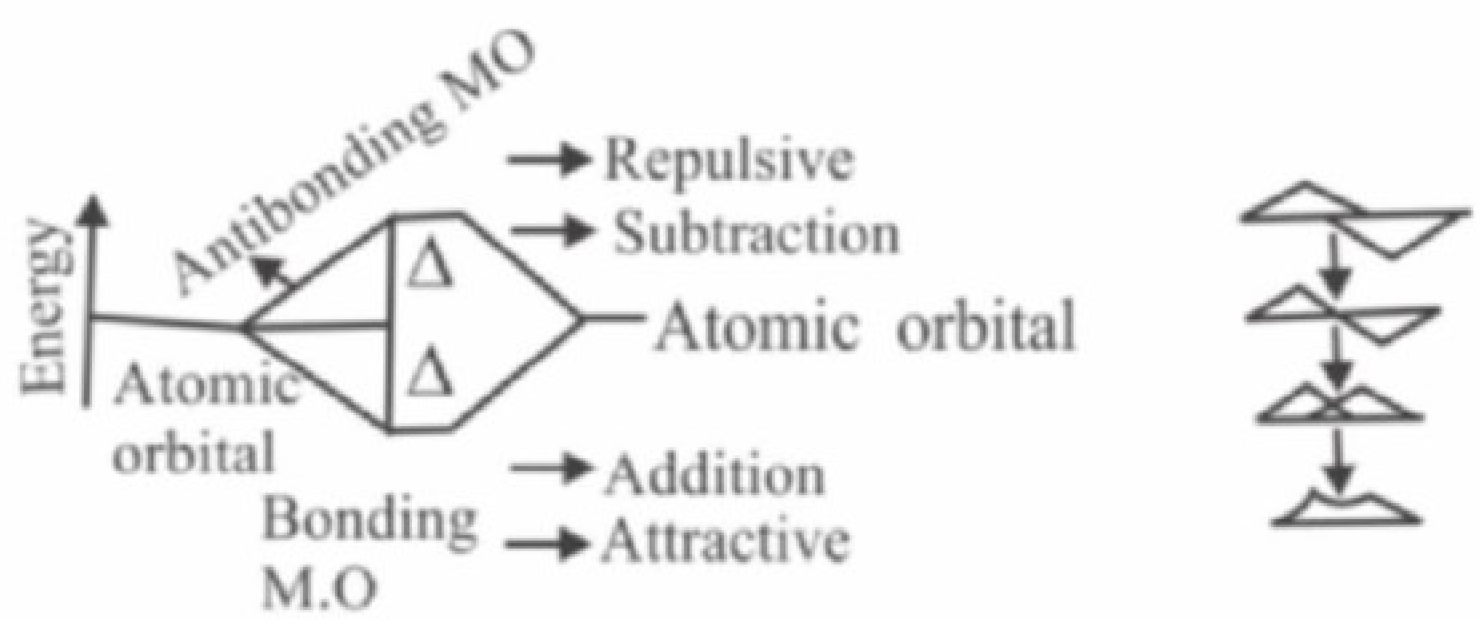
i. An electron in a MO is under the influence of nuclei of two or more atoms of a molecule.
ii. They are polycentric.
iii. These are formed by the combination of atomic orbitals of comparable energies.
iv. They are less or more stable than A.O
v. They have complex shapes
vi. They are represented by $\sigma, \sigma^*, \pi, \pi^*$ etc.

(6) Linear combination of atomic orbitals (LCAO)

Molecular orbitals of a molecule are obtained by the linear combinations of atomic orbitals of the bonded atoms. When waves are combined they may interact either constructively or destructively. If the two identical waves are added, they combine constructively to produc the wave with double the amplitude and same wavelength. Conversely, if they are subtracted, they combine destructively to produce the wave with zero amplitude.



When two atomic orbitals overlap they can be in phase (added) or out of phase(subtracted). If they overlap in phase,constructive interaction occurs in the region between two nuclei and a **bonding orbital** is produced. When they overlap out of phase destructive interference reduces the probability of finding an electron in the region between the nuclei and **antibonding orbital** is produced.



Formation of bonding and antibonding molecular orbitals

This can be shown mathematically also. suppose ψ_A and ψ_B represent the amplitude wave functions of the electron waves of the atomic orbitals of the two atoms A and B respectively.

Case I: when two waves are in phase, i.e., constructive interference occurs, the waves are added so that the amplitude of the new waves is $\phi = \psi_A + \psi_B$

Case II : when the two waves are out of phase, i.e., destructive interference occurs, the

waves are subtracted from each other so that the amplitude of the new wave is,

$$\phi' = \psi_A - \psi_B$$

The probable electron density is given by the square of the amplitude, therefore we have

$$\phi^2 = (\psi_A + \psi_B)^2 = \psi_A{}^2 + \psi_B{}^2 + 2\psi_A\psi_B,$$

and

$$\phi'^2 = (\psi_A - \psi_B)^2 = \psi_A{}^2 + \psi_B{}^2 - 2\psi_A\psi_B$$

i.e., $\phi^2 > \psi^2 A + \psi_B^2$

Whereas $\phi'^2 < \psi_A{}^2 + \psi_B{}^2$

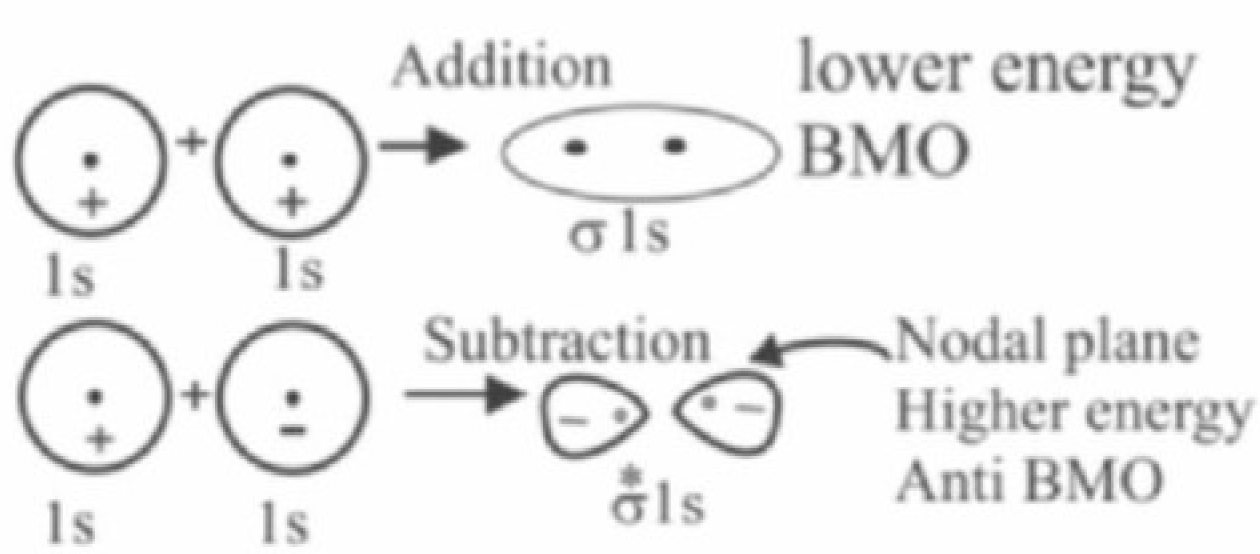
The above relation shows that the probability of finding the electrons in the bonding molecular orbital increases whereas it decreases in the antibonding molecular orbitals. In other words, it can be said that electron density is high between the nuclei of two bonded atoms due to increased attraction in case of bonding molecular orbital whereas most of the electron density is located away from the space between the nuclei due to repulsion in case of antibonding molecular orbital.

(7) Formation of Bonding and Antibonding Molecular orbitals (LCAO method)

1. In the MO theory, orbitals are identified as σ or π depending upon the type of the symmetry of the molecular orbital
2. A sigma (σ) MO is one that has cylindrical symmetry around the internuclear axis i.e., it does not show any change of sign on rotation through $180°$ about the axis.
3. It can be said that a sigma MO has no nodal plane (in which the electron density is zero) along the inter nuclear axis

(A) σ molecular orbital

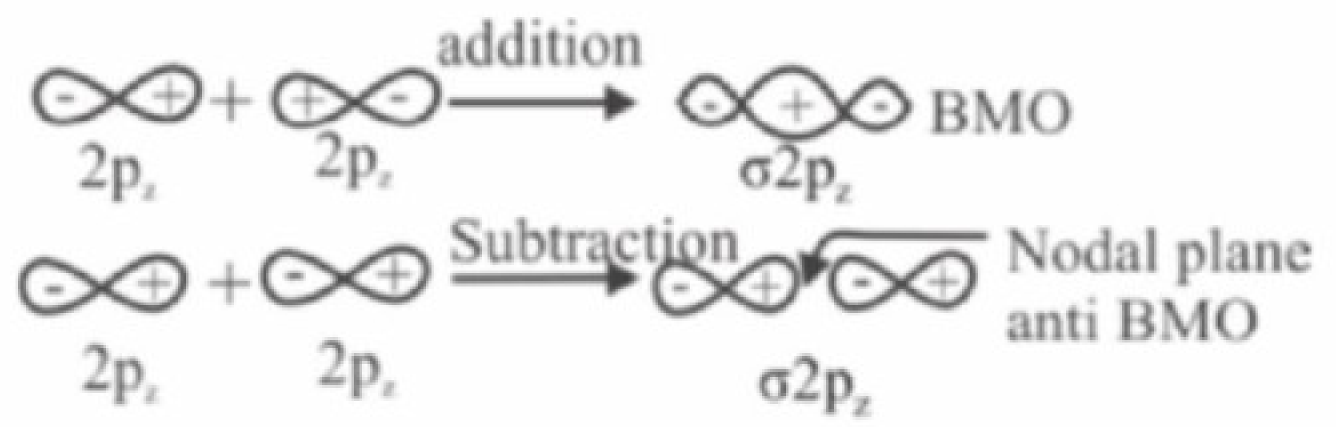
(a) combination of s-orbitals



formation of σ1s nd σ*1s bonding, antibonding molecular orbitals

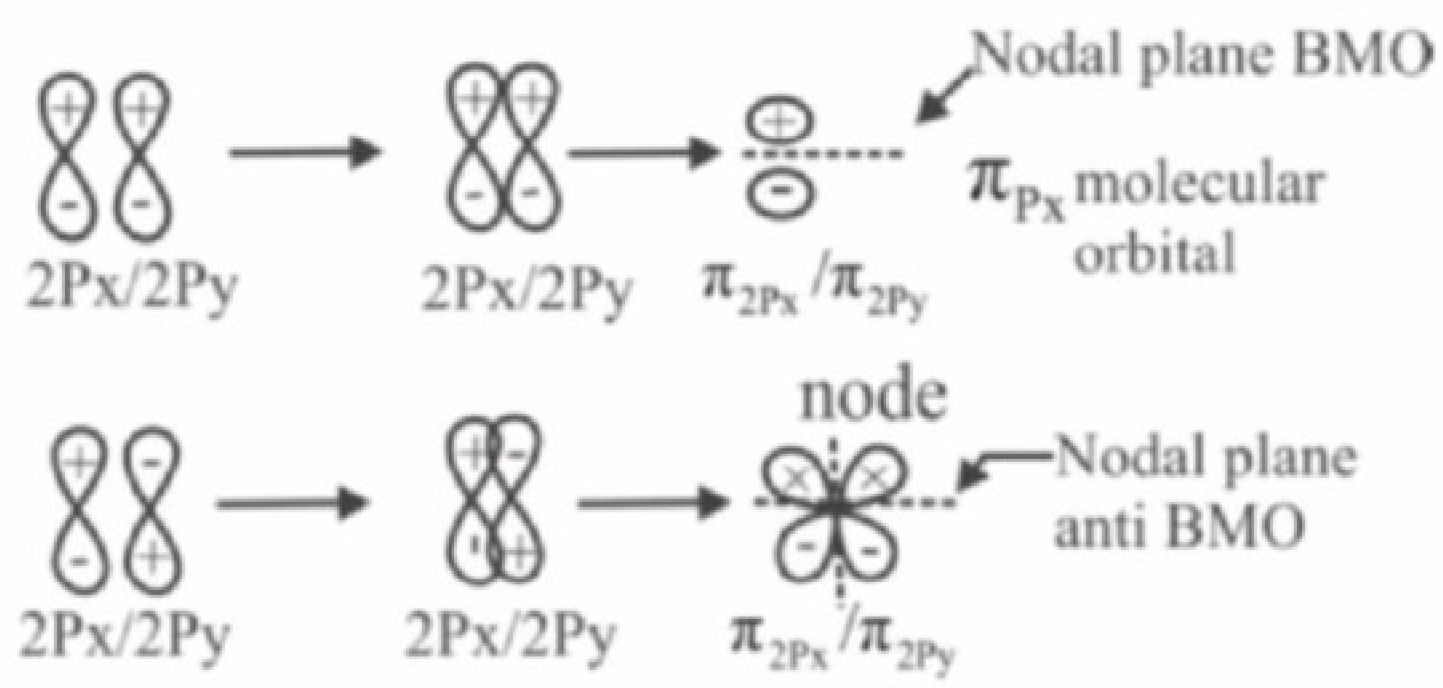
4. The bonding orbital is designated simply as σ orbital and antibonding as σ^*
5. Such a sigma (σ) orbital is also formed, when any two p-atomic orbitals overlap in end-on (along their axis) positions.

(b) End on overlaping of p- orbitals



6. Since, the energy of a molecular orbital is directly related to the number of nodal planes, the π-orbital is more energetic than the σ-orbial. This explains why a π-bond is a weaker bond than σ-bond.

(B) π (pi) Molecular orbital



(8) (a) Difference between Bonding and Anti-bonding Molecular orbitals

Bonding MO

i. Bonding molecular orbital is formed by the addition of overlaping of atomic orbitals. The wave function of the bonding MO may be writen as:

$$\psi(MO) = \psi_A + \psi_B$$

ii. They are formed when the lobes of the combining atomic orbitals have same sign

iii. It has greater electron density in the region between the two nuclei of bonded atoms

iv. The forces in this orbital tend to bring the two nuclei of the atoms together. Therefore, the electrons in the bonding MO contribute to attraction between the two atoms

v. It passess lower energy than the isolated atomic orbitals.

vi. Generally it does't have nodal plane.

vii. They favour bond formation.

viii. Electron placed in a BMO stabilises a Molecule.

Antibonding MO

i. Anti- bonding molecular orbital is formed by the subtraction of overlaping of atomic orbitals. The wave function for the anti-bonding MO may be written as

$$\psi(MO) = \psi_A - \psi_B$$

ii. They are formed when the lobes of the combining atomic orbitals have opposite sign

iii. It has lesser electron density in the region between the two nuclei of the atoms.

iv. The forces in this orbital push the nuclei apart therefore, the electron in anti bonding molecular orbital contribute to repulsion between the atoms.

v. It possess higher energy than the isolated atomic orbitals

vi. It always have a nodal plane between 2 nuclei of bonded atoms

vii. They didn't favour bond formation

viii. Electron placed in a ABMO do not stabilises a molecule.

(8) (b) Differences between σ - Molecular orbital and π -Molecular orbital

σ - Molecular orbital

1. It is formed by the overlap of atomic orbitals along the internuclear axis
2. Due to head on overlap, the overlaping is maximum
3. It consists of one electron cloud
4. Its electron cloud is symmetrical about the inter nuclear axis.

π - Molecular orbital

1. It is formed by the side wise overlaping of atomic orbitals
2. Due to side way overlap, overlapping is less.
3. It consists of 2e$^-$ clouds one lying above and the other lying below a plane passing through the nucleus
4. Its e$^-$ cloud is not symmetrical about the inter nuclear axis.

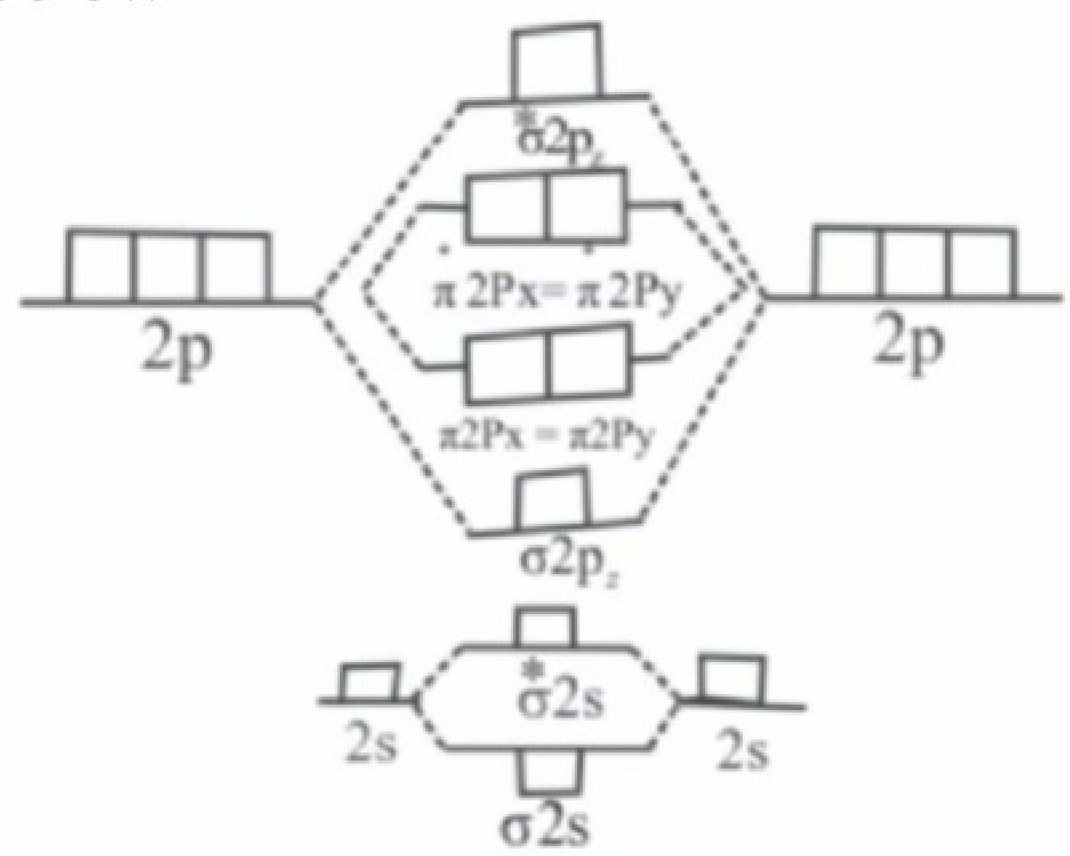
(9) Relative Energies of Molecular orbitals and filling of Electrons

1. Two general criteria, which determine the energy of the molecular orbitals are
(i) Initial energy of the atomic orbitals, and
(ii) The extent of the overlap of atomic orbitals
2. It is obvious that molecular orbitals formed from lower energy atomic orbitals have lower energy than the molecular orbitals formed from higher energy atomic orbitals.
3. As the σ overlap is much more effective than π overlap, $\sigma p-$ molecular orbital is of lowest energy, even though originally all the three p- orbitals are of equal energy.
4. The relative energies of the MO are obtained experimentally from the spectroscopic data.
5. The sequence in the order of increasing energy for more than 14 e$^-$ molecules (O_2, F_2) as follows:

$$\sigma 1s < \overset{*}{\sigma} 1s < \sigma 2s < \overset{*}{\sigma} 2s < \sigma 2P_z < \pi 2P_x$$

$$= \pi 2P_y < \overset{*}{\pi} 2P_x = \overset{*}{\pi} 2P_y < \overset{*}{\sigma} 2P_Z$$

6. **Energy diagram for O_2, F_2, Ne_2 is shown below**



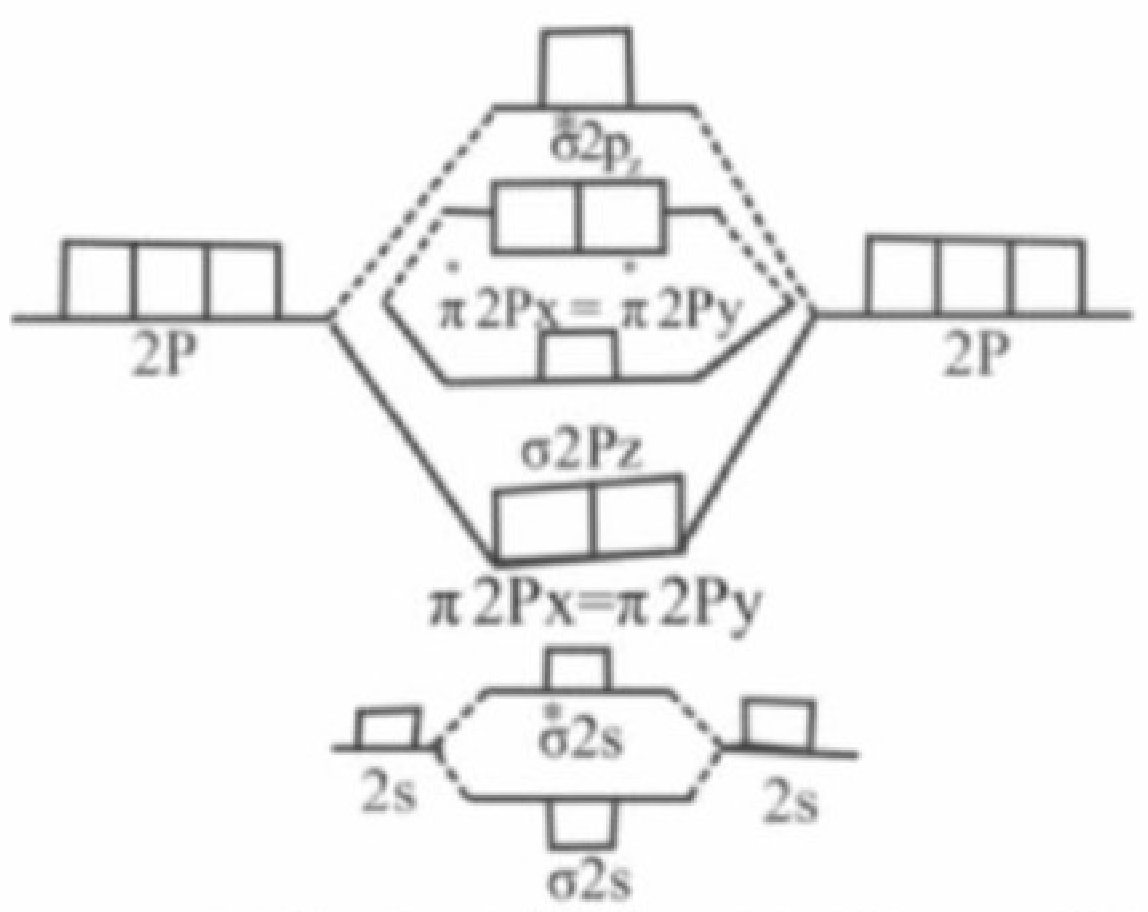
molecular orbital energy level diagram for O_2,F_2 and Ne_2

7. It may be noted that $\pi 2P_x$ and $\pi 2P_y$ bonding molecular orbitals are degenerate (i.e., having equal energy but different orientation). Similarly, $\pi^* 2P_x$ and $\pi^* 2P_y$ antibonding molecular orbitals are also degenerate.
8. It has been found experimentally that in some of the diatomic molecules $\sigma 2P_z$ MO is higher in energy than $\pi 2P_x$ and $\pi 2P_y$ MO's. Therefore, the order of increasing energy of these MO's changes for ≤ 14 e$^-$ molecules

$$\sigma 1s < \overset{*}{\sigma} 1s < \sigma 2s < \overset{*}{\sigma} 2s < \pi 2P_x = \pi 2P_y$$

$$\sigma 2P_z < \overset{*}{\pi} 2P_x = \overset{*}{\pi} 2P_y < \overset{*}{\sigma} 2P_z$$

9. The main difference between the two type of sequences in energy level is that for molecules O_2, F_2 and Ne_2 (Hypothetical) the $\sigma 2P_z$ MO is lower in energy than $\pi 2P_x$ and $\pi 2P_y$.
10. In case of molecule of Li_2, Be_2, (Hypothetical) B_2, C_2 and N_2 molecules the $\sigma 2P_z$ MO has higher energy than $\pi 2P_x$ and $\pi 2P_y$ MO's
11. The new energy diagram is as shown below for ≤ 14 e^- molecules:



molecular orbital energy diagram for Li_2,Be_2, B_2, C_2 & N_2 molecule

(10) Rules for filling of electrons in the Molecular orbitals

The filling of electrons in various M.O's follow similar rules as for filling A.O. Since MO belongs to entire molecule, for filling a M.O the total number of electrons are taken into consideration and accommodated in molecular orbitals according to following rules.

(a) Aufbau principle

The MO of lower energy is filled up first.

(b) Pauli's exclusion principle

Each MO can accommodate a maximum of two electrons having opposite spins.

(c) Hund's rule

Whenever two equal energy MO's are available, electrons prefer to remain un paired . This is particularly significant for π -orbitals because π -bonding and π -anti bonding MO have equal energies. Each orbital filled with single electron then only pairing will takes place.

(11) Stability of molecules in terms of bonding and antibonding electrons

Since electrons in bonding orbitals (N_b) increase the stability of the molecule where as these in antibonding orbitals (N_a) decrease its stability. Stability of the molecule on the whole depends upon their relative numbers Thus,

(i) It $N_b > N_a$, the molecule is stable.

(ii) It $N_b < N_a$, the molecule is unstable.

(iii) Even it $N_b = N_a$, the molecule is unstable.

This is due to the fact that antibonding effect is some what stronger than the bonding effect.

(12) Stability of molecules in terms of bond order

1. The relative stability of molecule is further evaluated by a Parameter known as bond order (B.O.)
2. B.O. can be defined as number of covalent bonds formed in a molecule.
3. B.O. is given by one half of the difference between the number of electrons in bonding orbitals and those in anibonding orbitals.
4. Bond order = 1/2 [NO. of electrons in bonding orbitals - NO. of electrons in anti bonding orbitals] $(N_b - N_a)/2$.
5. The bond order of 1,2 and 3 corresponds to single, double and triple bonds, respectively. It may be mentioned that according to MOT, even a fractional bond order is possible. Thus,

- Stability of molecule $\propto$ bond order
- Dissociation energy $\propto$ bond order

- Bond length $\propto \frac{1}{\text{bond order}}$

(13) Magnetic property

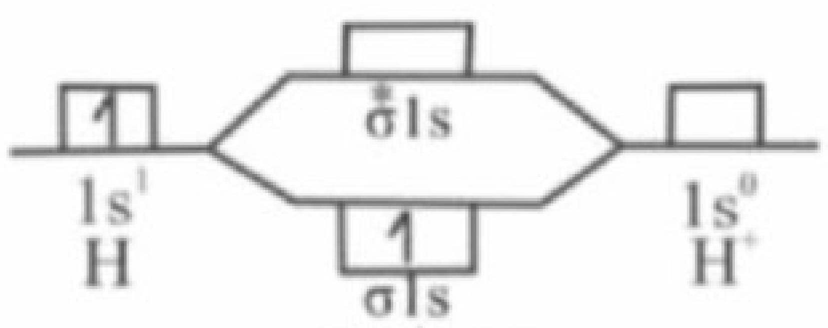
(a) When electrons in M.O are paired are diamagnetic

(b)When electrons in M.O are unpaired are Paramagnetic. More the number of unpaired electrons in the molecule greater is the paramagnetism of the subsance.

(14) Molecular orbital Configuration - Homonuclear diatamic Species

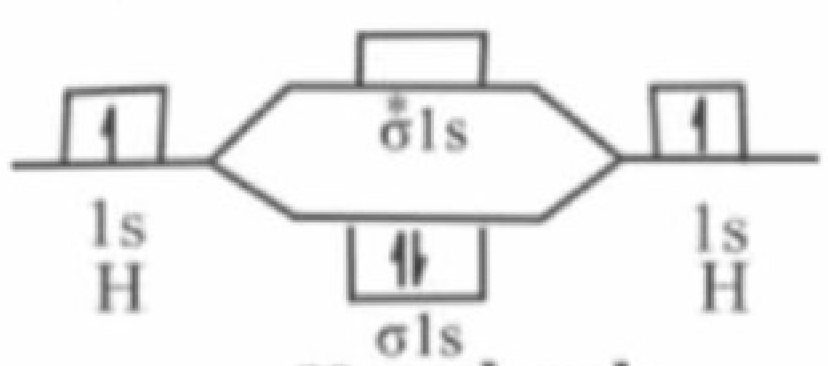
These type of ions have two identical atoms linked together of A_2 type

(1)H_2^+ ion: This ion has one hydrogen atom and one H^+ ion linked together. Each has 1s orbital. Using LCAO method two 1s orbitals will combine to give two MO's σ 1s and $\sigma^* 1s$. The only one electron will be accommodated on σ 1s. Thus, bond order for H_2^+=(1-0)/2 H_2^+ ion can exist but it is unstable it is paramagnetic in nature.



H_2^+ ion

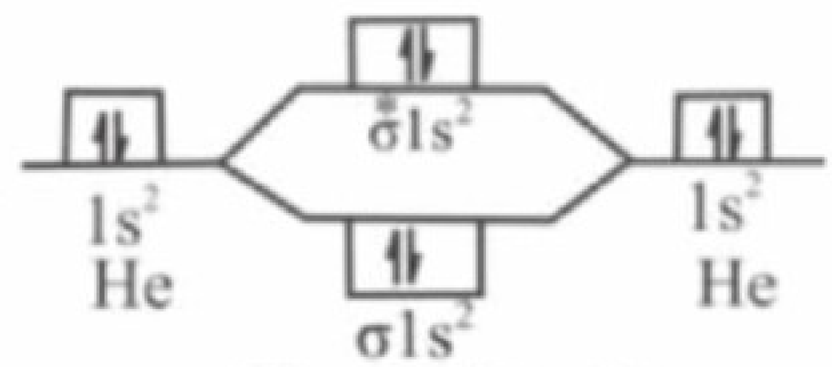
(2) H_2 molecule: It is formed from 1s atomic orbitals of two H atoms. The atomic orbitals (1s) will combine to form two molecular orbitals 1s. Two electrons are placed in σ 1s and $\overset{*}{\sigma}1s$ remains vacant. Thus bond order for H_2 = (2-0)/2 = 1. Is stable and diamagnetic in nature.



H_2 molecule

(3) He_2 molecule: It is formed by linking two He atoms both have 1s orbitals. These will combine to form two molecular orbitals $\sigma(1s)$ and $\overset{*}{\sigma}(1s)$ .Four available electrons are accommodated as $\sigma(1s)^2$ and $\overset{*}{\sigma}(1s^2)$ $(1s^2)$. Thus bond order for He_2Molecule.

$= \frac{1}{2}(2-2) = 0$. Hence He_2 does not exist.



He_2 molecule

15. N_2, N_2^+, N_2^- and N_2^{2-}

(a) N_2 : N_2 molecule has 14 electrons.
Electronic configuration (E.C) of N_2 :

$$(\sigma 1s)^2(\overset{*}{\sigma}1s)^2(\sigma 2s)^2(\overset{*}{\sigma}2s)^2(\pi 2px)^2 = (\pi 2py)^2(\sigma 2pz)^2$$

$$B.O = \frac{1}{2}[Nb - Na]$$

$$= \frac{1}{2}[10-4] = 3$$

$$N \equiv N - 3 \text{ bonds}$$

The molecule is diamagnetic in nature. Because it has no unpaired electrons.

(b) N_2^+: N_2^+ has 13 electrons, Electronic configuration

$$(\sigma 1s)^2(\overset{*}{\sigma}1s)^2(\sigma 2s)^2(\overset{*}{\sigma}2s)^2(\pi_{2px})^2 = (\sigma_{2py})^2\sigma_{2pz}^1$$

$$\text{Bond order} = \frac{1}{2}[9-4] = \frac{5}{2} = 2.5.$$

The species is paramagnetic in nature

(c) N_2^- : It has 15 electrons.

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\pi_{2px})^2 = (\pi_{2py})^2 (\sigma_{2pz})^2(\overset{*}{\pi}_{2px})^1$$

$$\text{Bond order} = \frac{1}{2}[10-5] = \frac{5}{2} = 2.5$$

The species is paramagnetic in nature due to presence of one unpaired electron in $\overset{*}{\pi}$ MO.

(d) N_2^{2-} = It has16 electrons

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\sigma_{2pz})^2(\pi_{2px})^2 =$$

$$(\pi_{2py})^2(\overset{*}{\pi}_{2px})^1 = (\overset{*}{\pi}_{2py})^1$$

$$\text{B.O} = \frac{1}{2}[10-6] = 2$$

The species is paramagnetic in nature

(e) Among N_2, N_2^+, N_2^- and N_2^{2-}

The most stable is N_2(B.O is 3)

The Least stable is N_2^{2-} (B.O is 2)

The species N_2^+ and N_2^- have same bond order but in N_2^- number of electrons in antibonding M.O's is more than the number of electrons in N_2^+. Therefore stability order in decreasing order is as follows:

$$N_2, N_2^+, N_2^-, N_2^{2-} \xrightarrow{\text{Stability in decreasingorder}}$$

16. O_2 , O_2^+, O_2^- and O_2^{2-}

(a) O_2 = 16 electrons

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2 = (\sigma_{2pz})^2(\pi_{2px})^2$$

$$(\pi_{2py})^2(\overset{*}{\pi}_{2px})^1 = (\overset{*}{\pi}_{2py})^1$$

$$B.O = \frac{1}{2}[10-6] = 2$$

The molecule is paramagnetic because lt has two unpaired electrons in antibonding MO_{2px} MO π_{MO} orbitals.

(b) O_2^+ = 15 electrons

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\sigma_{2p_2})^2(\pi_{2px})^2 = (\pi_{2py})^2$$

$$(\overset{*}{\pi}_{2p_x})^2 = (\overset{*}{\pi}_{2p_y})^1$$

$$B.O = \frac{1}{2}[10-5] = 2.5$$

Paramagnetic nature. It has 1 unpaired e^-

(c) O_2^- =17 electrons

$$(\sigma_1)^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\sigma_{2pz})^2$$

$$(\pi_{2px})^2 = (\pi_{2py})^2(\overset{*}{\pi}_{2px})^2 = (\overset{*}{\pi}_{2py})^1$$

$$\text{B.O.} = \frac{1}{2}[10-7] = 1.5$$

The ion is paramagnetic in nature.

(d) O_2^{2-} =18 electrons

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\sigma_{2pz})^2$$

$$(\pi_{2px})^2 = (\pi_{2py})^2(\overset{*}{\pi}_{2px})^2 = (\overset{*}{\pi}_{2py})^2$$

$$= \frac{1}{2}[10-8] = 1$$

The Species is diamagnetic in nature because it has no unpaired electron.

(e) The stability in decreasing order is as follows

$$\begin{matrix} & O_2^+ & O_2 & O_2^- & O_2^{2-} \\ \text{B.O} & 2.5 & 2 & 1.5 & 1 \end{matrix} \xrightarrow{\text{Stability in decreasing order}}$$

(f) Experimentally it has been found that bond length of O_2^+ is 112 pm $(O_2, 121\text{ Pm})$ and bond dissociation energy of O_2^+ (625kJ/mole) is more than the O_2 (498.7 kJ/mole).

17. F_2 and Ne_2 molecules

(a) $F + F = F_2$: It has 18 electrons.

$$(\sigma_1)^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2\sigma(2Pz)^2$$

$$^2(\pi_{2px})^2(\pi_{2py})^2(\overset{*}{\pi}_{2px})^2(\overset{*}{\pi}_{2py})^2$$

$$\text{Bond order} = \frac{1}{2}[10-8] = 1$$

The molecule is diamagnetic because it has all paired electrons in M.O's.

(b) Ne_2 molecule: It has 20 electrons

$$Ne_2 = (\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\sigma_{2pz})^2$$

$$(\pi_{2px})^2 = (\pi_{2py})^2(\overset{*}{\pi}_{2px})^2 = (\overset{*}{\pi}_{2py})^2(\overset{*}{\sigma}_{2pz})^2$$

$$\text{Bond order } = \frac{1}{2} = \frac{10-10}{2} = 0$$

Hence Ne_2 molecule is unstable and cannot exist.

18. Bonding in some Heteronuclear Diatomic Molecules: Heteronuclear diatomic species have two different atoms linked together. The general structure of such molecule is AB where B is more eletronegative than A. In which A and B belong to only atoms of second period elements.

In these molecules, electrons in bonding MO spend more time near the more electronegative atom. On the order hand, electrons in antibonding molecular orbital are closer to the less electronegative atom. Electronic Configuration of AB and it ion depends on the number of electrons of the species

Case 1: If number of electrons is ≤ 14 then Configuration is

$$(\sigma_{1s})(\overset{*}{\sigma}_{1s})(\sigma_{2s})(\overset{*}{\sigma}_{2s})(\pi_{2px} = \pi_{2py})\left(\sigma_{2pz}\right)$$

$$(\overset{*}{\pi}_{2px} = \overset{*}{\pi}_{2py})(\overset{*}{\sigma}_{2pz})$$

Case2: If number of electrons is >14 then cofiguration is

$$(\sigma_{1s})(\overset{*}{\sigma}_{1s})(\sigma_{2s})(\overset{*}{\sigma}_{2s})\left(\sigma_{2pz}\right)(\pi_{2px} = \pi_{2py})$$

$$(\overset{*}{\pi}_{2px} = \overset{*}{\pi}_{2py})(\overset{*}{\sigma}_{2pz})$$

1. NO molecule

- Total number of electrons in NO molecule is 7+8=15.Configuration is:

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\sigma_{2pz})^2(\pi_{2px})^2 =$$

$$(\pi_{2py})^2(\overset{*}{\pi}_{2px})^1$$

- Bond order of NO molecule

$$= \frac{1}{2}[Nb - Na] = \frac{1}{2}[10-5] = 2.5$$

- Molecule is paramagnetic in nature

2. NO^- Molecule

- Number of electrons = 7+8+1=16
- Electronic configration is

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\sigma_{2pz})^2(\pi_{2px})^2 =$$

$$(\pi_{2py})^2(\overset{*}{\pi}_{2px})^1 = (\overset{*}{\pi}_{2py})^1$$

- Bond order :

$$B.O = \frac{1}{2}[10-6] = 2$$

- The molecule is paramagnetic
- NO molecule is more stable than NO^- ion

3. CO molecule

- Number of electrons $6+8=14$
- Electronic configuration is:

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\pi_{2px})^2(\pi_{2py})^2(\sigma_{2pz})^2$$

$$B.O = \frac{1}{2}[10-4] = 3$$

- The molecule is highly stable and diamagnetic in nature

19. Cyanide ion (CN^-)

- Number of electrons $6+7+1=14$,
- Electronic configuration is:

$$(\sigma_{1s})^2(\overset{*}{\sigma}_{1s})^2(\sigma_{2s})^2(\overset{*}{\sigma}_{2s})^2(\pi_{2px})^2$$

$$= (\pi_{2py})^2(\sigma_{2pz})^2$$

$$B \cdot O = \frac{1}{2}(10-4) = 3$$

- The ion is highly stable and diamagnetic in nature. N_2, CO & CN^- has same Bond order.

20. Some Important Points

- Bond order of molecular species having odd number of electrons (1,3,5,7,9,13,15,19 e^-) is always in fractions, not in whole number.
- Bond order is zero if species having 4 or 8 or 20 electrons.
- If bond order is in fraction, then molecular species is always paramagnetic, exception to these are B_2,O_2 molecule.

$$(B_2 = 10\,e,\ B.O = 1) \text{ and}$$

$$(O_2 = 16\,e',\ B.O = 2)$$

Where bond order is whole number but both are paramagnetic.

21. Remember the following scale for bond order

6	7	8	9	10	11	12	13	N_2 14	15	16	17	18	(No of electrons)
1	0.5	0	0.5	1	1.5	2	2.5	3.0	2.5	2.0	1.5	1	(Bond order)

M.O. Electronic configuration of diatomic Species up to 14 Electrons

Sl No	molecule (or)ion	Total No. of electrons	σ 1s	σ* 1s	σ 2s	σ* 2s	π $2p_x$	π $2p_y$	σ $2p_z$	N_b	N_a	Bond order $=(N_b-N_a)/2$	Magnetic nature
1	H_2	2	2							2	0	1.0	Dia (D)
2	H_2^+	1	1							1	0	0.5	Para (P)
3	He_2	4	2	2						2	2	0.0	–
4	He_2^+	3	2	1						2	1	0.5	P
5	Li_2	6	2	2	2					4	2	1.0	D
6	Be_2	8	2	2	2	2				4	4	0.0	–
7	B_2	10	2	2	2	2	1	1		6	4	1.0	P
8	C_2	12	2	2	2	2	2	2		8	4	2.0	D
9	N_2	14	2	2	2	2	2	2	2	10	4	3.0	D
10	O_2^{2+}	14	2	2	2	2	2	2	2 (Same as N_2)	10	4	3.0	D
11	N_2^+	13	2	2	2	2	2	2	1	9	4	2.5	P
12	CN^-	14	2	2	2	2	2	2	2(Same as N_2)	10	4	3.0	D

M.O. Electronic configuration of diatomic molecules having more than 14 Electrons

Sl No	molecule (or)ion	Total no of e^-	σ 1s	σ* 1s	σ 2s	σ* 2s	σ $2p_z$	π $2p_x$	π $2p_y$	π* $2p_x$	π* $2p_y$	σ* $2p_z$	N_b	N_a	Bond order	Magnetic nature
1	O_2	16	2	2	2	2	2	2	2	1	1		10	6	2.0	P
2	O_2^+	15	2	2	2	2	2	2	2	1			10	5	2.5	P
3	NO	15	2	2	2	2	2	2	2	1			10	5	2.5	P
4	O_2^-	17	2	2	2	2	2	2	2	2	1		10	7	1.5	P
5	O_2^{2-}	18	2	2	2	2	2	2	2	2	2		10	8	1.0	D
6	F_2	18	2	2	2	2	2	2	2	2	2		10	8	1.0	D
7	Ne_2	20	2	2	2	2	2	2	2	2	2	2	10	10	0.0	–

Easy memory tricks -M.O.T

B.O ∝	B.S ∝	B.E ∝	$\frac{1}{BL}$ ∝	B.A	M.pt B.pt
↓	↓	↓	↓	↓	
Bond order	Bond Stability	Bond Energy	Bond Length	Bond Angle	

Total number of electrons in molecule / ion and its bond order value:

No of e$^-$	1	2	3	4	5	6	7	8	9	10
Bond order	0.5	1	0.5	0	0.5	1	0.5	0	0.5	1.0
No of e$^-$	11	12	13	14	15	16	17	18	19	20
Bond order	1.5	2	2.5	3	2.5	2.0	1.5	1.0	0.5	0.0
Molecules	(a) N_2^+ N_2 N_2^- (b) O_2^{2+} O_2^+ O_2 O_2^- O_2^{2-} (c) NO CO									

easy way to remember

No. of e$^-$						Bond order
			4	8	20	0
1	3	5	7	9	19	0.5
		2	6	10	11	1.0
				11	17	1.5
				12	16	2.0
				13	15	2.5
					14	3

Magnetic properties of molecules (or) ions: ions :-

Total electron sum is

even no of e$^-$ = Diamagnetic molecule

odd no of e$^-$ = Paramagnetic molecule

$$\begin{pmatrix} 10e^- \to B_2 & and \\ 16e^- \to O_2 & exceptional \end{pmatrix}$$

OR

Bond order

$= 0 \to$ does not exist $\to He_2, Ne_2, Be_2$

B.O $= 0,1,3 \to$ dia ,

B.O $= 2$, and fractional like 0.5, 1.5, 2.5 $\to$ para

Bond order of resonance structures

(1)

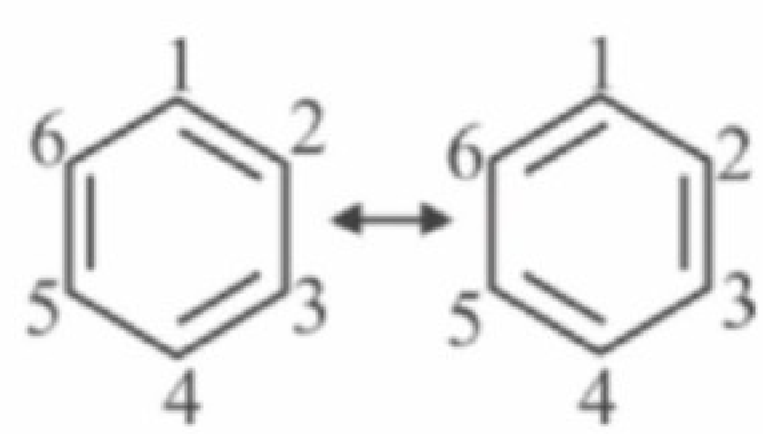
$$B.O = \frac{\text{No. of Resonating Bonds (R.B)}}{\text{No. of Resonance Structures (R.S)}}$$

(2) $$B.O = \frac{\text{Group Number Roman (G.N)}}{\text{No.of Oxygen Atoms (O.A)}}$$

(3) $$B.O = \text{Oxygen valency} + \frac{\text{Charge on ion}}{\text{No.of surrounding atoms}}$$

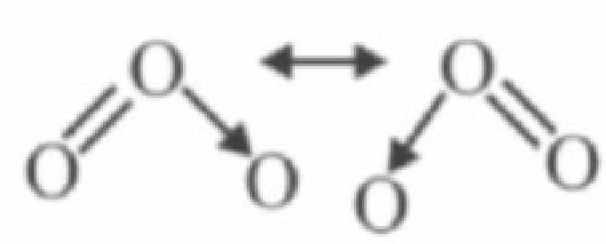
Apply 1st Formula

(1) C_6H_6



$$= \frac{3}{2} = 1.5$$

(2) O_3



$$= \frac{3}{2} = 1.5$$

- Apply 2nd formula to the following molecules or ions.

(3) $CO_3^{-2} = \frac{4}{3} = 1.33$ **(4)** $CO_2 = \frac{4}{2} = 2$

(5) $CO = 14e^- = 3\left(\frac{N_b - N_a}{2}\right)$

(6) $SiO_4^{-4} = \frac{4}{4} = 1$ **(7)** $PO_4^{-3} = \frac{5}{4} = 1.25$

(8) $SiO_4^{-2} = \frac{6}{4} = 1.5$ **(9)** $SO_3 = \frac{6}{3} = 2$

(10) $ClO_4^- = \frac{7}{4} = 1.75$

Apply 3rd Formula:

(11) ClO_3^-

$$= 2 + \left(\frac{-1}{3}\right)$$

$$= 1.66$$

(12) ClO_2^-

$$= 2 + \left(\frac{-1}{2}\right)$$

$$= 2 + (-0.5)$$

$$= 1.5$$

Exercise

1. The ion that is isoelectronic with CO and having same bond order is
(1) CN^- (2) O_2^+ (3) O_2^- (4) N_2^+

2. Which of the following is paramagnetic:-
(1) O_2^- (2) CN^- (3) CO (4) NO^+

3. Which has the bond order in fraction:-
(1) O_2 (2) He^+ (3) CO (4) CN

4. Bond order in C_2^+ is
(1) $\frac{1}{2}$ (2) $\frac{2}{3}$ (3) $\frac{3}{2}$ (4) 1

5. In the following which of the two are paramagnetic
(a) N_2 (b) CO (c) B_2 (d) NO_2
(1) a and c (2) b and c
(3) c and d (4) b and d

6. In which of the species, bond order increase on removing one electron
(a) NO (b) CN^- (c) O_2 (d) CO
Correct answer is
(1) b and d (2) a and c
(3) b, d and c (4) b and c

7. Increasing order of bond length in NO, NO^+ and No^- is
(1) No> No>No^+
(2) No^+<No<No^-
(3) No <No^+< No^-
(4) No<No^+=NO^-

8. Molecular orbital electronic configuration of Be_2, will be
(a) $kk, \sigma 2s^2$
(b) $kk, \sigma 2s^2, \overset{*}{\sigma} 2s^2$
(c) $\sigma 1s^2, \overset{*}{\sigma} 1s^2 \sigma 2s^2, \overset{*}{\sigma} 2s^2$
(d) $\sigma 1s^2, \overset{*}{\sigma} 1s^2 \sigma 2s^2, \overset{*}{\sigma} 2p_x^2$
Correct answer is
(1) a,b (2) b,c (3) c,d (4) a,c

9. In which of the following set, the value of bondorder will be 2.5
(1) O_2^+,NO, NO^{+2}, CN
(2) CN, NO^{+2},CN^-,F_2
(3) O_2^+, NO^{+2}, O_2^{+2}.CN^-
(4) O_2^{-2},O_2^-,O_2^+,O_2

10. Which of the following ion is diamagnetic
(1) O_2^- (2) O_2^{-2} (3) O_2 (4) O_2^{+2}

11. The paramagnetic property of oxygen is well explained by
(1) Molecular orbital theory

(2) Resonance theory
(3) Valence bond theory
(4) VSEPR theory

12. Of the following species which has the highest bond order and shortest bond length NO, NO^+, NO^{2+}, NO^-
(1) NO only
(2) Bond order of NO is highest and bond length of NO^{2+} is shortest
(3) NO^+ only
(4) NO^{2+} only

13. The bond order of CO molecule on the basis of molecular orbital theory is
(1) zero (2) 2 (3) 3 (4) 1

14. The diamagnetic molecule is
(1) Super oxide ion
(2) Oxygen molecule
(3) Carbon molecule
(4) Unipostive ion of nitrogen molecule

15. The energy of $\sigma 2s$ orbital is greater, than $\sigma 1s*$ orbital because.
(1) $\sigma 2s$ orbital is bigger than $\sigma 1s*$ orbital
(2) $\sigma 2s$ orbital is a bonding orbital where as is $\sigma 1s*$ is an antibonding orbital
(3) $\sigma 2s$ orbital has a greater value of n than $\sigma 1s*$ orbital
(4) None

16. The molecule having one unpaired electron is
(1) NO (2) CO (3) CN^- (4) O_2

17. Which of the following group of molecules have $2\frac{1}{2}$ bond order
(1) N_2^{-2}, O_2^{-2}, CO
(2) N_2^+, O_2^+, NO
(3) C_2^{-2}, BN, O_2
(4) CN^-, NO^+, O_2^{+2}

18. The no of antibonding electron pair in O_2^- is
(1) 4 (2) 3 (3) 8 (4) 10

19. On the basis of molecular orbital theory which molecules does not exist
(1) H_2 (2) He_2 (3) He_2^+ (4) Li_2

20. Maximum bond energy will be shown by the species
(1) O_2^+ (2) O_2 (3) O_2^- (4) O_2^{-2}

21. Which of the following species will have the minimum bond energy
(1) N_2 (2) N_2^- (3) N_2^+ (4) N_2^{-2}

22. Which of the following ion has not bond order of 2.5
(1) O_2^- (2) O_2^+ (3) N_2^+ (4) N_2^-

23. N_2 and O_2 are converted into monoanions, N_2^- and O_2^- respectively which of the following statement is wrong
(1) In N_2^-, N-N bond weakens
(2) In O_2^-, O-O bond order increases
(3) In O_2^-, O-O bond order decreases
(4) N_2^- becomes paramagnetic

24. N_2 and O_2 are converted into monocations, N_2^+ and O_2^+ respectively which of the following is worng
(1) In N_2^+, N-N bond weakens
(2) In O_2^+, the O-O bond order increases
(3) In O_2^+, paramagnetism decreases
(4) N_2^+ becomes diamagnetic

25. In a homonuclear molecule which of the following set of orbitals are degenerate
(1) σ_{2s} and σ_{1s}
(2) π_{2px} and π_{2py}
(3) π_{2px} and σ_{2pz}
(4) σ_{2pz} and $\pi *_{2px}$

26. Oxygen molecule is paramagnetic because
(1) Bonding electrons are more than antibonding electrons
(2) It contains unpaired electrons
(3) Bonding electrons are less than antibonding electrons
(4) None of these

27. Which one is paramagnetic from the following?
(1) O_2^- (2) NO
(3) Both (a) and (b) (4) CN^-

28. Out of the following which has smallest bond length
(1) O_2 (2) O_2^+ (3) O_2^- (4) O_2^{2-}

29. Which molecule has the highest bond order?
(1) N_2 (2) Li_2 (3) He_2 (4) O_2

30. The molecular electronic configuration of H_2^- ion is
(1) $(\sigma 1s)^2$
(2) $(\sigma 1s)^2(\sigma^* 1s)^1$
(3) $(\sigma 1s)^2(\sigma^* 1s)^2$
(4) $(\sigma 1s)^3$

31. According to the molecular orbital theory,the bond order in C_2 molecule is
(1) 0 (2) 1 (3) 2 (4) 3

32. The molecular orbital configuration of a diatomic molecule is

$$\sigma 1^2 s \overset{*}{\sigma} 1s^2\ \sigma 2s^2 \overset{*}{\sigma} 2s^2\ \sigma 2p_z^2 \begin{Bmatrix} \pi 2p_x^2 \\ \pi 2p_y^2 \end{Bmatrix}.$$ It's

bond order is
(1) 3 (2) 2.5 (3) 2 (4) 1

33. According to molecular orbital theory,the paramagnetism of O_2 molecule is due to presence of
(1) unpaired electrons in the bonding σ molecular orbital
(2) unpaired electrons in the antibonding σ molecular orbital
(3) unpaired electrons in the bonding π molecular orbital
(4) unpaired electrons in the anti bonding π molecular orbital

34. Which of the following molecular orbitals has two nodal planes?
(1) $\sigma 2s$ (2) $\pi 2py$
(3) $\overset{*}{\pi} 2py$ (4) $\overset{*}{\sigma} 2px$

35. What is corrects sequence of bond order?
(1) $O_2^+ > O_2^- > O_2$ (2) $O_2^+ > O_2 > O_2^-$
(3) $O_2 > O_2^- > O_2^+$ (4) $O_2^- > O_2^+ > O_2$

36. Match the following

Column -I	**Column -II**
(A) B_2	(p) Paramagnetic
(B) N_2	(q) Diamagnetic
(C) O_2^-	(r) Bond order 1.5
(D) O_2	(s) Bond order 2

	A	B	C	D
(1)	p	q	r	s
(2)	q	p	s	r
(3)	p	s	r	q
(4)	p	r	s	q

37.

Molecule /Species	**Bond order**
(A) H_2	(p) 0
(B) Ne_2	(q) 1
(C) N_2	(r) 2
(D) O_2^-	(s) 3
	(f) 1.5

	A	B	C	D
(1)	q	p	s	f
(2)	q	s	f	p
(3)	p	q	r	f
(4)	s	p	q	f

38.

Column -I	**Column-II**
(A) H_2^+	(p) Diamgnetic
(B) CO	(q) Paramagnetic
(C) N_2	(r) B.O = 2
(D) O_2^{2-}	(s) B. O. = 3

	A	B	C	D
(1)	q	p	s	r
(2)	p	q	r	s
(3)	r	s	p	q
(4)	q	p	r	s

39. Correct order of bond dissociation energy is:-
(1) $N_2 > N_2^+ = N_2^-$
(2) $N_2^+ = N_2^- > N_2$
(3) $N_2 > N_2^+ > N_2^-$
(4) $N_2 > N_2^- > N_2^+$

40. Correct order of bond dissociation energy is:
(1) $O_2 > N_2 > CO$
(2) $O_2 > CO > N_2$
(3) $CO > N_2 > O_2$
(4) $N_2 > N_2^- > N_2^{2-}$

41. In a homonuclear diatomic molecule, higher the bond order, larger will be
(1) Bond length
(2) Bond strength
(3) Paramagnetic nature
(4) Ionic character

42. In which set of molecules all the species are paramagnetic?

(1) C_2^{2+}, O_2, N_2

(2) C_2^{2+}, O_2, NO

(3) C_2^{2+}, F_2, O_2

(4) C_2^{2+}, O_2, Li_2

43. From elementary molecular orbital theory we can give the electronic configuration of the singly positive nitrogen molecular ion N_2^+ as

(1) $\sigma(1s)^2 \overset{*}{\sigma}(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \sigma^*(2s)^2$ $\pi(2p)^4 \sigma(2p)^1$

(2) $\sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \sigma(2p)^1$ $\pi(2p)3$

(3) $\sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \pi(2p_x)^2$ $\pi(2p_y)^2 \sigma 2p_z$

(4) $\sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \pi(2p)^2$

44. The bond order of O_2^+ is the same as in

(1) N_2^+ (2) CN^- (3) CO (4) NO^+

45. The total number of electron that takes part in forming bonds in N_2 is

(1) 2 (2) 4 (3) 6 (4) 10

46. The bond length of the species O_2, O_2^+ and O_2^- are the order of

(1) $O_2^+ > O_2 > O_2^-$

(2) $O_2^+ > O_2^- > O_2$

(3) $O_2 > O_2^+ > O_2^-$

(4) $O_2^- > O_2 > O_2^-$

47. According to molecular orbital theory which of the following statement about the magnetic character and bond order is correct regarding O_2^+ ?

(1) Paramagnetic & bond order O_2

(2) Paramagnetic and bond order > O_2

(3) Dimagnetic and bond order > O_2

(4) Dimagnetic and bond order >O_2

48. The bond order in NO is 2.5. While that in NO^+ is 3. Which of the following statements is true for these two species?

(1) Bond length in NO^+ is equal to that in NO

(2) Bond length in NO is greater than in NO^+

(3) Bond length in NO^+ is greater than in NO

(4) Bond length is unpredictable

49. Which of the following is diamagnetic?

(1) Oxygen molecule

(2) Boron molecule

(3) N_2^+

(4) O_2^{2+}

50. Bond energies in NO, NO^+ and NO^- are in the order

(1) $NO^- > NO > NO^+$

(2) $NO > NO^- > NO^+$

(3) $NO^+ > NO > NO^-$

(4) $NO^+ > NO^- > NO$

51. In O_2^-, O_2 and O_2^{-2} molecular Species, the total number of antibonding electrons respectively are

(1) 7,6,8,

(2) 1,0,2

(3) 8,6,6

(4) 8,6,8

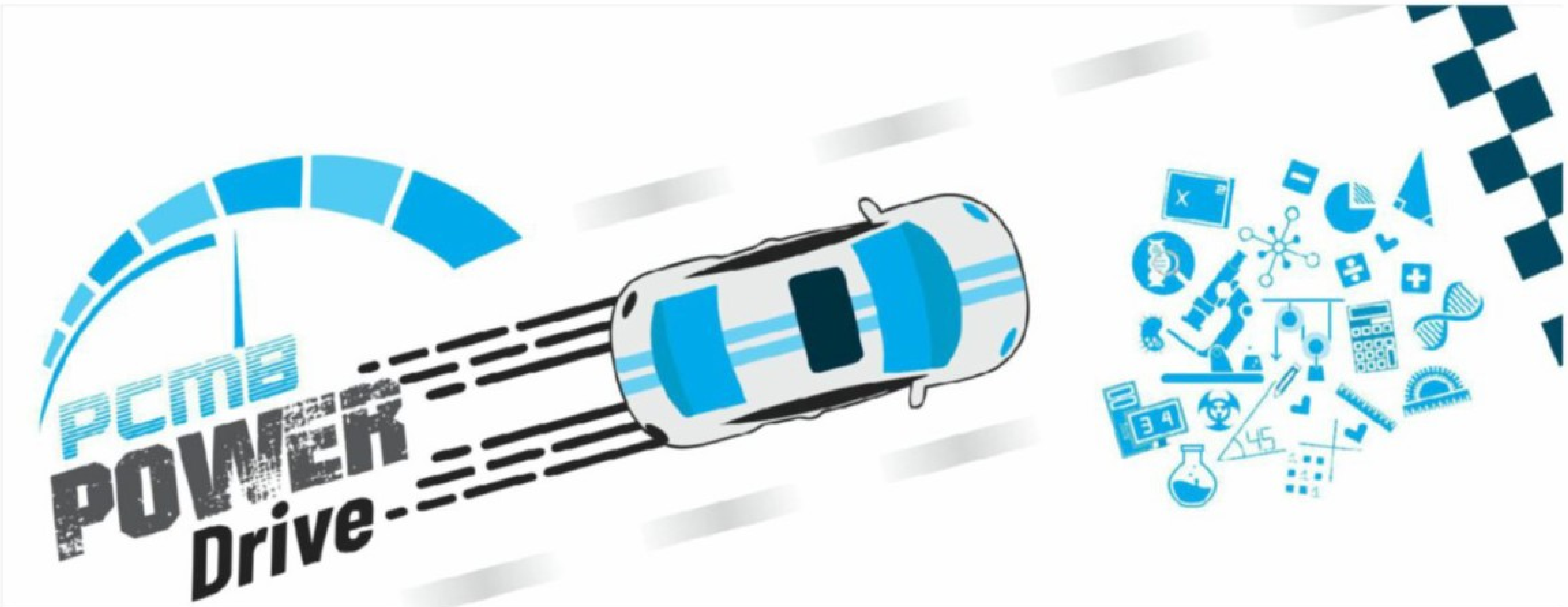
52. Which of the following is not paramagnetic

(1) O_2 (2) O_2^+

(3) O (4) O_2^-

ANSWER KEY

1. 1	**2.** 1	**3.** 4	**4.** 3	**5.** 3
6. 2	**7.** 2	**8.** 2	**9.** 1	**10.** 2
11. 1	**12.** 3	**13.** 3	**14.** 3	**15.** 3
16. 1	**17.** 2	**18.** 2	**19.** 2	**20.** 1
21. 4	**22.** 1	**23.** 2	**24.** 4	**25.** 2
26. 2	**27.** 3	**28.** 2	**29.** 1	**30.** 2
31. 3	**32.** 1	**33.** 4	**34.** 3	**35.** 2
36. 1	**37.** 1	**38.** 1	**39.** 1	**40.** 4
41. 2	**42.** 2	**43.** 3	**44.** 1	**45.** 3
46. 1	**47.** 2	**48.** 2	**49.** 4	**50.** 3
51. 1	**52.** 4			



SOLUTIONS (CLASS-XII)

- A solution may be described as a homogeneous mixture of a single phase containing two or more of the chemical species dispersed on a molecular state.
- A solution which contains only two components is called binary solutions.

(1) Concentration of solutions

(I) In percentage

(A) Mass percentage $\left(\frac{w_2}{W}\%\right)$

$$\text{Mass percent} = \frac{\text{Mass of solute}(w_2)}{\text{Mass of solution}(W)} \times 100$$

(B) Volume percent $\left(\frac{v_2}{V}\%\right)$

$$\text{Volume percent} = \frac{\text{Volume of solute}(v_2)}{\text{Volume of solution}(V)} \times 100$$

(C) Mass/Volume percent $\left(\frac{w_2}{V}\%\right)$

$$\text{Mass/Volume percent} = \frac{\text{Mass of solute}(w_2)}{\text{Volume of solution}} \times 100$$

(II) Mole fraction (X)

- $$X_{solute} = \frac{\text{Number of moles of solute}(n_2)}{\text{Total moles present in solution}}$$

$$= \frac{\text{No. of moles of solute}(n_2)}{\text{No.of moles of solute}(n_2) + \text{no.of moles of solvent}(n_1)}$$

$$= \frac{n_2}{n_1 + n_2}$$

(III) Molarity (M)

$$M = \frac{w_2}{(MW_2)(V_{(L)})} = \frac{W_2 \times 1000}{(MW_2)(V_{(mL)})}$$

[MW_2 = Molecular weight of solute]

(IV) Molality(m)

$$m = \frac{w_2}{(MW_2)(w_1(kg))} = \frac{w_2 \times 1000}{(MW_2)(w_1(g))}$$

(V) Normality (N)

$$N = \frac{w_2}{(EW_2)(V_{(L)})} = \frac{w_2 \times 1000}{(EW_2)(V_{(mL)})}$$

[EW_2 = Equivalent weight of solute]

- Dilution formula: $N_1V_1 = N_2V_2$
- $$N_{Mixture} = \frac{N_1V_1 + N_2V_2}{V_1 + V_2}$$

(2) Factors Affecting solubility of Gases in liquid

(I) Nature of gas and liquid

In polar solvents like water polar gases are more soluble whereas, solubility of non-polar gases is lesser (like dissolves like). Gases which can be liquified easily are comparatively more soluble in water.

(II) Temperature

Dissolution of gas in liquid is exothermic process so, on increasing the temperature solubility decreases.

(III) Pressure

On increasing the pressure solubility of gases in liquid increases. This effect is explained by Henry's law

Henry's Law

"The partial pressure of the gas in vapour phase (p) is proportional to the mole fraction of the gas (X) in the solution".

If we use the mole fraction of a gas in the solution as a measure of its solubility. It is expressed as $p = K_H X$. Here K_H is Henry's law constant.

- Higher is the value of K_H at a given pressure, lower is the solubility of the gas in the liquid.

Limitations of Henry's law

- Solubility of gases in liquid should not be too much
- Henry's law is applicable at high pressure and low temperature.

(3) Vapor pressure

- It is the equilibrium pressure exerted by the vapors on the liquid surface.
- At equilibrium,
  Rate of evaporation = Rate of condensation

Factors affecting vapour pressure of pure liquid

(I) Nature of the liquid

Intermolecular forces $\uparrow$ *es* & B.P. $\uparrow$ *es* & V.P. $\downarrow$ *es*

(II) Temperature

- ***Temperature $\uparrow$ es so V.P. $\uparrow$ es***
- Variation of Vapour Pressure of a liquid with Temperature is given by **Clausius** and **Clapeyron Equation**.

$$\log\frac{P_2}{P_1} = \frac{\Delta H_v}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right]$$

ΔH_v = Enthalpy of vapourisation of liquid

P_2 = Vapour pressure at T_2

P_1 = Vapour pressure at T_1

R = Gas constant

(III) Addition of a non-volatile solute to a volatile solvent

Vapor pressure of the pure liquid decreases by the addition of the non-volatile solute because of the following two reasons:

(a) attraction between the solute and solvent molecules

(b) reduction in the number of solvent molecules per unit area of the surface

(4) Raoult's law

- **Raoult's law:** for a solution of volatile liquids at a given temperature states that, "The partial vapour pressure of each component of the solution is directly proportional to its mole fraction."

$$p_1 \propto X_1 \qquad p_2 \propto X_2$$

$$p_1 = p_1^0 X_1 \qquad p_2 = p_2^0 X_2$$

Where p_1^0, p_2^0, X_1 & X_2 represents the vapour pressures and mole fraction of the pure components 1 and 2, respectively.

$$P_{Total} = p_1 + p_2 = p_1^0 X_1 + p_2^0 X_2 = p_1^0 + (p_2^0 - p_1^0)X_2$$

Thus, total vapour pressure over the solution can be related to the mole fraction of any one component.

(I) Ideal Solutions

A solution which obeys Raoult's law at all concentrations and at all temperatures is called an ideal solution.

$$p_A = p_A^0 X_A \quad \text{and} \quad p_B = p_B^0 X_B$$

$$P_{Total} = p_A^0 X_A + p_B^0 X_B$$

Characteristics

(i) $\Delta H_{mix} = 0$

(ii) $\Delta V_{mix} = 0$

In an ideal solution of two components say A_2 and B_2, all cohesive forces between A-A, B-B and A-B are identical.

Eg: Benzene and toluene
Ethyl bromide and ethyl chloride
n - Heptane and n- hexane
Chlorobenzene and bromobezene

(II) Non Ideal Solutions

(A) Non Ideal solution showing Positive

Deviation from Raoult's Law

$p_A > p_A^0 X_A$ and $p_B > p_B^0 X_B$

$\Rightarrow P_{Total} > p_A^0 X_A + p_B^0 X_B$

Characteristics

(i) $\Delta H_{mix} > 0$,

(ii) $\Delta V_{mix} > 0$

(iii) A-B inter molecular interactions which are weaker than A-A and B-B intermolecular interactions.

Eg: Carbon tetrachloride + Benzene
Carbon tetrachloride + Chloroform
Carbon tetrachloride + Toluene
Ethanol + Water

(B) Non-Ideal solution showing Negative Deviation from Raoult's Law

$p_A < p_A^0 X_A$ and $p_B < p_B^0 X_B$

$\Rightarrow P_{Total} < p_A^0 X_A + p_B^0 X_B$

Characteristics

(i) $\Delta H_{mix} < 0$

(ii) $\Delta V_{mix} < 0$

(iii) A-B intermolecular interactions which are stronger than A-A and B-B intermolecular interactions.

Eg: Methanol + Acetic acid
Acetic acid + Pyridine
Chloroform + Benzene
Chloroform + Diethyl ether
Acetone + Aniline
HCl + Water
HNO_3 + Water

(5) Azeotropic Mixture or Constant boiling mixture

- These are the liquid mixtures which distill off without change in their composition.
- Azeotropism observed in non-ideal solution at a given pressure for the fixed composition
- At this condition separation of two liquids is not possible by fractional distillation.
- Azeotropic mixtures can be of two types

(I) Minimum Boiling Azeotrope

(A) B.P. of azeotrope mixture is less than both the two pure components.

(B) It is formed by the solution which shows positive deviation.

Eg: $C_2H_5OH(96\%) + H_2O(4\%)$

B.P. of mixture is $78°C$ and B.P. of water $= 100°C$ and B.P. of ethanol $= 78.6°C$.

(II) Maximum boiling azeotrope

(A) B.P. of the mixture is more than both the two pure components

(B) It is observed in those solution which show negative deviation.

Eg: $HNO_3(68\%) + H_2O(32\%)$

B.P. of mixture = $120.6°C$, B.P. of water $= 100°C$ and B.P. of $HNO_3 = 80°C$.

(6) Colligative properties

By definition, colligative properties are those which depend on the number of nonvolatile solute species relative to the total number of species present in the solution. These properties do not depend upon the nature of solute species.

There are four colligative properties

(I) Relative lowering of vapor pressure $(RLVP)$

(II) Elevation in boiling point (ΔT_b)

(III) Depression in freezing point (ΔT_f)

(IV) Osmotic pressure (π)

(I) Relative lowering of Vapour Pressure

Vapour Pressure of solution is equal to mole fraction of non volatile solute in it.

$$\frac{p^0 - p}{p^0} = X_{solute} \quad \text{or} \quad \frac{p^0 - p}{p^0} = \frac{n_{solute}}{n_{solute} + n_{solvent}}$$

$p°$ - V.P. of pure solvent

p - V.P. of solution containing non-volatile solute

X_{solute} – Mole fraction of solute

For dilute solutions $n_{solvent} >>> n_{solute}$

Thus, $$\frac{p^0 - p}{p^0} = \frac{n_{solute}}{n_{solvent}}$$

$$\frac{p^0 - p}{p^0} = \frac{\text{molality x } M_{solvent}}{1000}$$

[$M_{solvent}$ is molecular weight of solvent]

(II) Elevation in Boiling point (ΔT_b)

- If T_b is the boiling point of the solution and T_b^o is the boiling point of the solvent, the difference $T_b - T_b^o$ is called the elevation in boiling point(EBP). Thus, EBP is

$$\Delta T_b = T_b - T_b^o$$

$$\boxed{\Delta T_b = K_b \text{ x molality}}$$

Where K_b is molal elevation constant, depends on nature of solvent

$$\boxed{\Delta T_b = K_b \times \frac{w_{solute}}{M_{solute}} \times \frac{1000}{w_{solvent}}}$$

(III) Depression of Freezing point (ΔT_f)

- If the T_f is the freezing point of the solution and T_f^o is the freezing point of the solvent, the difference $T_f^o - T_f$ is called the freezing point depression(DEP). Thus, DFP is

$$\Delta T_f = T_f^o - T_f$$

$$\boxed{\Delta T_f = K_f \text{ x molality}}$$

Where K_f is molal depression constant, depends on the nature of solvent.

$$\boxed{\Delta T_f = K_f \times \frac{w_{solute}}{M_{solute}} \times \frac{1000}{w_{solvent}}}$$

- At freezing point, equilibrium exist between liquid solvent and solid solvent.
- Thermodynamic relation for K_b & K_f

$$K_f = \frac{R(T_f^o)^2 M_{solvent}}{1000\,\Delta_{fusion} H} \quad \text{and}$$

$$K_b = \frac{R(T_b^o)^2 M_{solvent}}{1000\,\Delta_{vap} H}$$

(IV) Osmotic Pressure

- **Osmosis**
  It is the spontaneous phenomena in which solvent particles move from lesser concentrated solution to higher concentrated solution through a semi-permeable membrane(SPM)
- **The pressure required to just stop the in flow of solvent into the solution seperated by a semipermeable membrane** is known as Osmotic pressure.
- Vant-Hoff's equation for dilute solutions

$$\boxed{\pi V = nRT}$$

$$\Rightarrow \pi V = \frac{w}{M} RT$$

Where, w = Weight of solute
M = Molecular weight of solute and
R = 0.0821 L atm $mol^{-1}K^{-1}$

- Isotonic solutions : At a given temperature solutions of same osmotic pressure are called isotonic solutions i.e., $\pi_1 = \pi_2$
  Eg : Blood is isotonic with saline (0.9% w/v NaCl solution)
- If $\pi_1 \neq \pi_2$, solution with higher osmotic pressure forms hypertonic solution where solution is with lower osmotic pressure known as hypotonic solution.
- The solvent particles moves from hypotonic to hypertonic
- To just stop the osmosis external pressure should be applied on more concentrate solution and

$$P_{ext} = \pi_2 - \pi_1$$

(7) Abnormal molar mass

Colligative property and molar mass of solute are inversely proportional to each other. Van't Hoff introduced a factor **'i'** in the equations to equalise the experimental value and calculated value.

$$\text{Van't Hoff factor}(i) = \frac{\text{Experimental value of colligative property}}{\text{Calculated value of colligative property}}$$

$$= \frac{\text{Normal molar mass}}{\text{Observed molar mass}}$$

(I) For solutes undergoing Dissociation

Total no of particles after dissociation

$$= 1 - \alpha + n\alpha = [1 + (n-1)\alpha]$$

$$i = \frac{\text{no.of particles after dissociation}}{\text{no.of particles before dissociation}}$$

$$i = \frac{[1+(n-1)\alpha]}{1}$$

$\Rightarrow \boxed{\alpha = \frac{i-1}{n-1}}$ 'α' is degree of dissociation or ionisation.

(II) For solutes which undergo association

Total particles after association $= 1 - \alpha + \frac{\alpha}{n}$

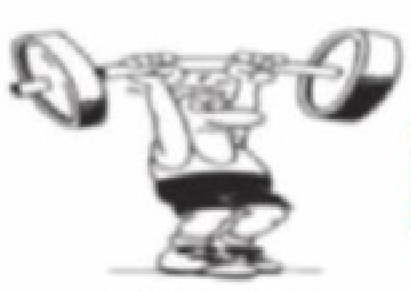
Thus

$$i = \frac{1-\alpha\left(1-\frac{1}{n}\right)}{1} \Rightarrow \boxed{\alpha_{\text{association}} = \frac{i-1}{\frac{1}{n}-1}}$$

- If the solution contains more than one species, then the molar mass determined from any of the colligative properties is the number average molar mass.
- Collagative properties including Van't Hoff factor (i)

(A) $\frac{P^\circ - P}{P^\circ} = iX_2$ (B) $\Delta T_b = iK_b m$

(C) $\Delta T_f = iK_f m$ (D) $\pi = iCRT$



Exercise

1. When the solute is present in trace quantities the following expression is used?
(1) Gram per million
(2) Nanogram percent
(3) Microgram percent
(4) Parts per million

2. 3.42 g of a substance of molecular weight 342 is present in 250g of water. Molality of this solution is
(1) 0.4m (2) 0.04 m
(3) 0.8 m (4) 4m

3. 20 mL of 0.5 M HCl is mixed with 20 ml of 6.6 M $BaCl_2$ the concentration of Cl^- ion in solution is
(1) 0.2 M (2) 6.85 M
(3) 0.02 M (4) 0.06 M

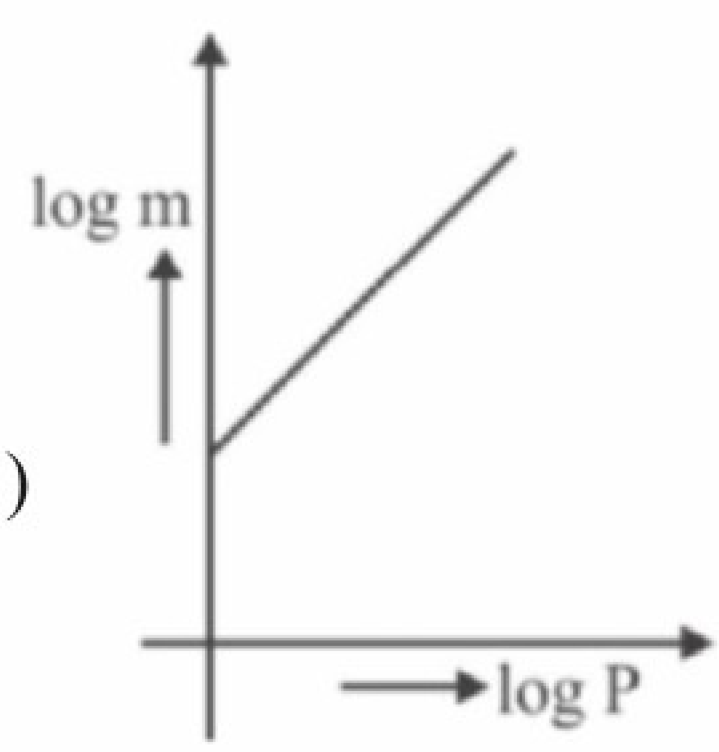
4. The density of NH_4OH solution is found to be 0.6 g/mL. It contains 35% by mass of NH_4OH. The normality of the solution is:
(1) 10 N (2) 4.8 N
(3) 0.6 N (4) 6 N

5. 250 mL of a sodium carbonate solution contains 2.65 grams of Na_2CO_3. 10 ml of this solution is added to x mL of water to obtain 0.001 M Na_2CO_3 solution. What is the value of x in mL?
(Molecular weight of $Na_2CO_3 = 106$)
(1) 1000 (2) 990 (3) 9990 (4) 90

6. A solution of $Al_2(SO_4)_3 \{d = 1.253 g/mL\}$ contains 22% salt by weight. The molarity, normality, and molality of the solution is, respectively
(1) 0.825 M, 48.3 N, 0.805 m
(2) 0.805 M, 4.83 N, 0.825 m
(3) 4.83 M, 4.83 N, 4.83 m
(4) None

7. Four gases like H_2, He, CH_4 and CO_2 have Henry's constant values (K_H) are 69.16, 144.97, 0.413 and 1.67, respectively. The gas which is more soluble in liquid is
(1) He (2) CH_4 (3) H_2 (4) CO_2

8. Which of the following curves represents the Henry's law? (wher m = mass of gas in solvent)

(1) 

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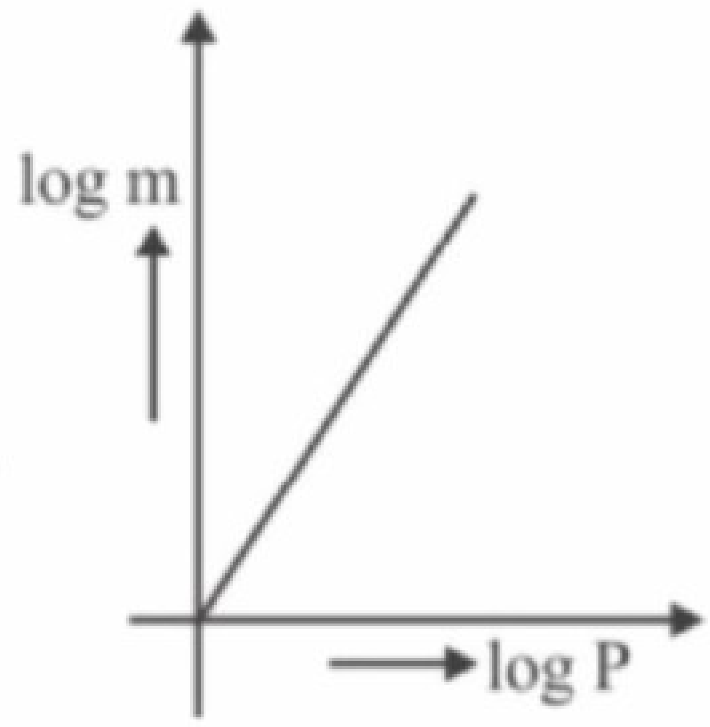

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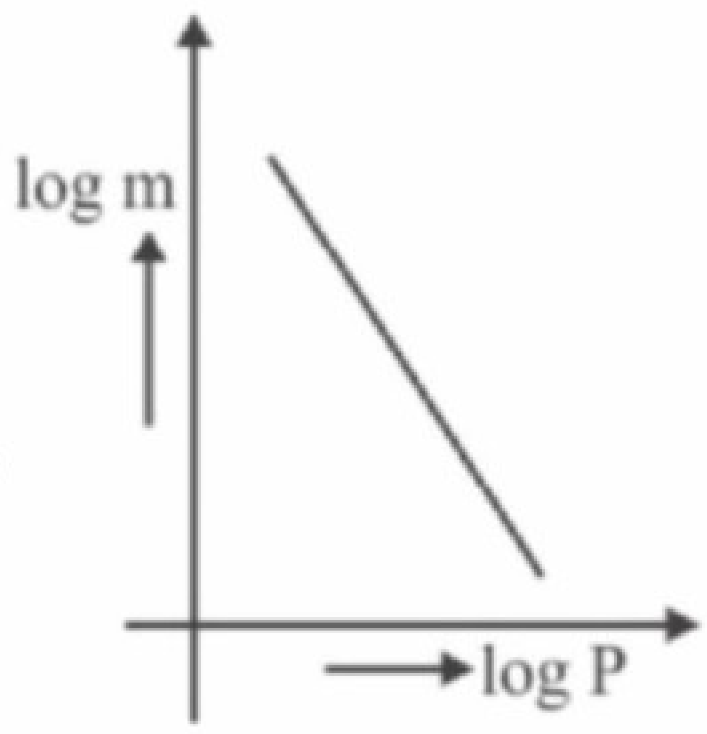

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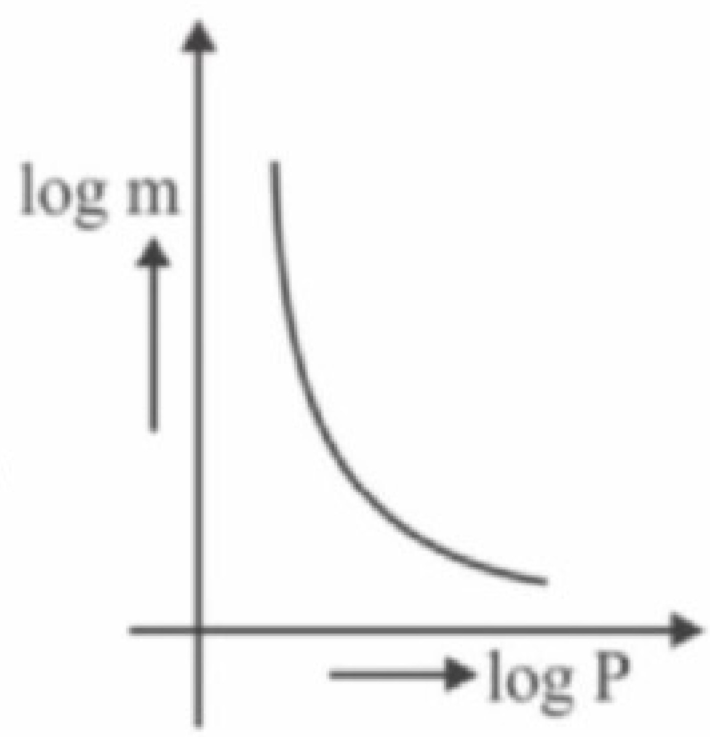
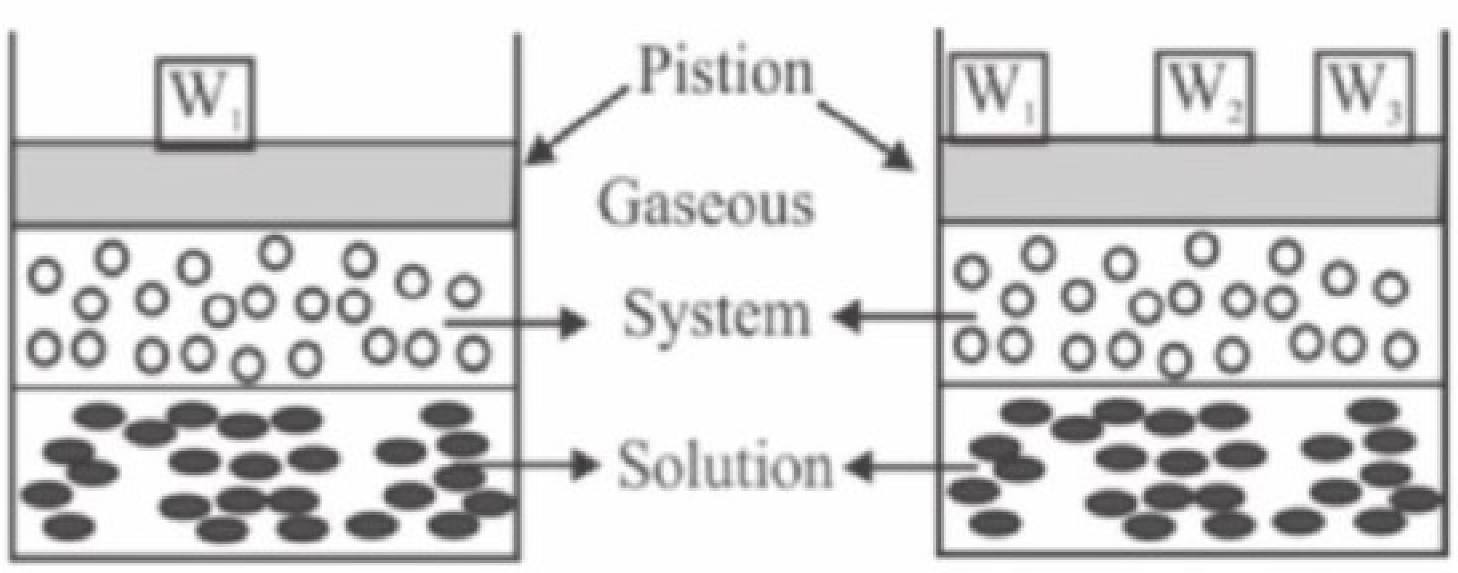


9.



Identify the correct statement about the given diagram.

(1) The pressure increases over the solution phase by compressing the gas to a smaller volume.

(2) There is increase in the number of gaseous particle per unit volume over the solution by increasing the pressure.

(3) By applying the pressure, there is increase in the rate of gaseous particles which are striking the surface of solution for entering into the solution.

(4) All of the above information is correct.

10. If liquids A and B form an ideal solution then

(1) The entropy of mixing is zero.

(2) The Gibbs free energy and the entropy of mixing are zero each.

(3) The Gibbs free energy and the enthalpy of mixing are zero each.

(4) The enthalpy of mixing is zero.

11. Which of the following shows positive deviation in non-ideal solution?

(1) C_6H_6 *and* $C_6H_5CH_3$

(2) HCl *and* HNO_3

(3) $CHCl_3$ *and* C_2H_5OH

(4) $CHCl_3$ *and* CH_3COCH_3

12. The pair of solutions which shows negative deviation in non-ideal solution is

(1) $CHCl_3 + CH_3COCH_3$

(2) $CH_3COCH_3 + C_6H_5NH_2$

(3) $CHCl_3 + C_6H_6$

(4) All the above

13. If two liquids A and B form minimum boiling azeotrope at some specific composition then

(1) A - B interactions are stronger than those between A - A or B - B

(2) Vapour pressure of solution increases because more number of molecules of liquids A and B can escape from the solution

(3) Vapour pressure of solution decreases because less number of molecules of only one of the liquids escape from the solution

(4) A - B interactions are weaker than those between A - A or B - B

14. At $25°C$, the total pressure of an ideal solution obtained by mixing 3 mole of A and 2 mole of B, is 184 torr. What is the vapour pressure (in torr) of pure B at the same temperature (vapour pressure of pure A at $25°C$ is 200 torr)?

(1) 180 (2) 160 (3) 16 (4) 100

15. Two liquids having vapour pressures P_1^0 and P_2^0 in pure state in the ratio of 2 : 1 are mixed in the molar ratio of 1 : 2. The ratio of their moles in the vapour phase would be

(1) 1 : 1 (2) 1 : 2
(3) 2 : 1 (4) 3 : 2

16. At a given temperature,

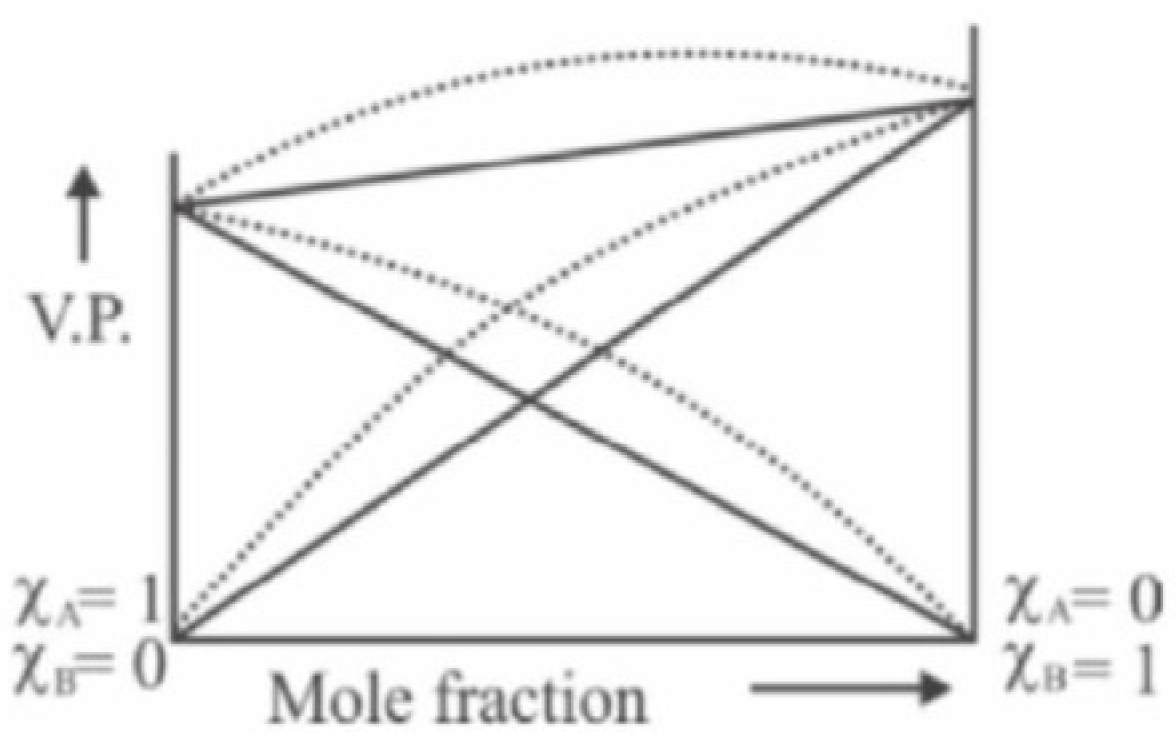
I. Vapour pressure of a solution containing non- volatile solute is proportional to mole fraction of solvent

II. Lowering of vapour pressure of solution containing non volatile solute is proportional to mole fraction of solute

III.Relative lowering of vapour pressure is equal to mole fraction of solute. The correct combination is

(1) I (2) I, II (3) I, II, III (4) II, III

17. Vapour phase diagram for a solution is given below if dotted line represents deviation



Correct observation for this solution

(1) ΔH_{mix}:+ve (2) ΔS_{mix}:+ve
(3) ΔV_{mix}:+ve (4) All of these

18. For a binary ideal liquid solution, the total vapour pressure of the solution is given as:

(1) $P_{total} = P_A^o + (P_A^o - P_B^o)x_B$

(2) $P_{total} = P_A^o + (P_A^o - P_B^o)x_B$

(3) $P_{total} = P_A^o + (P_A^o - P_B^o)x_A$

(4) $P_{total} = P_A^o + (P_B^o - P_A^o)x_B$

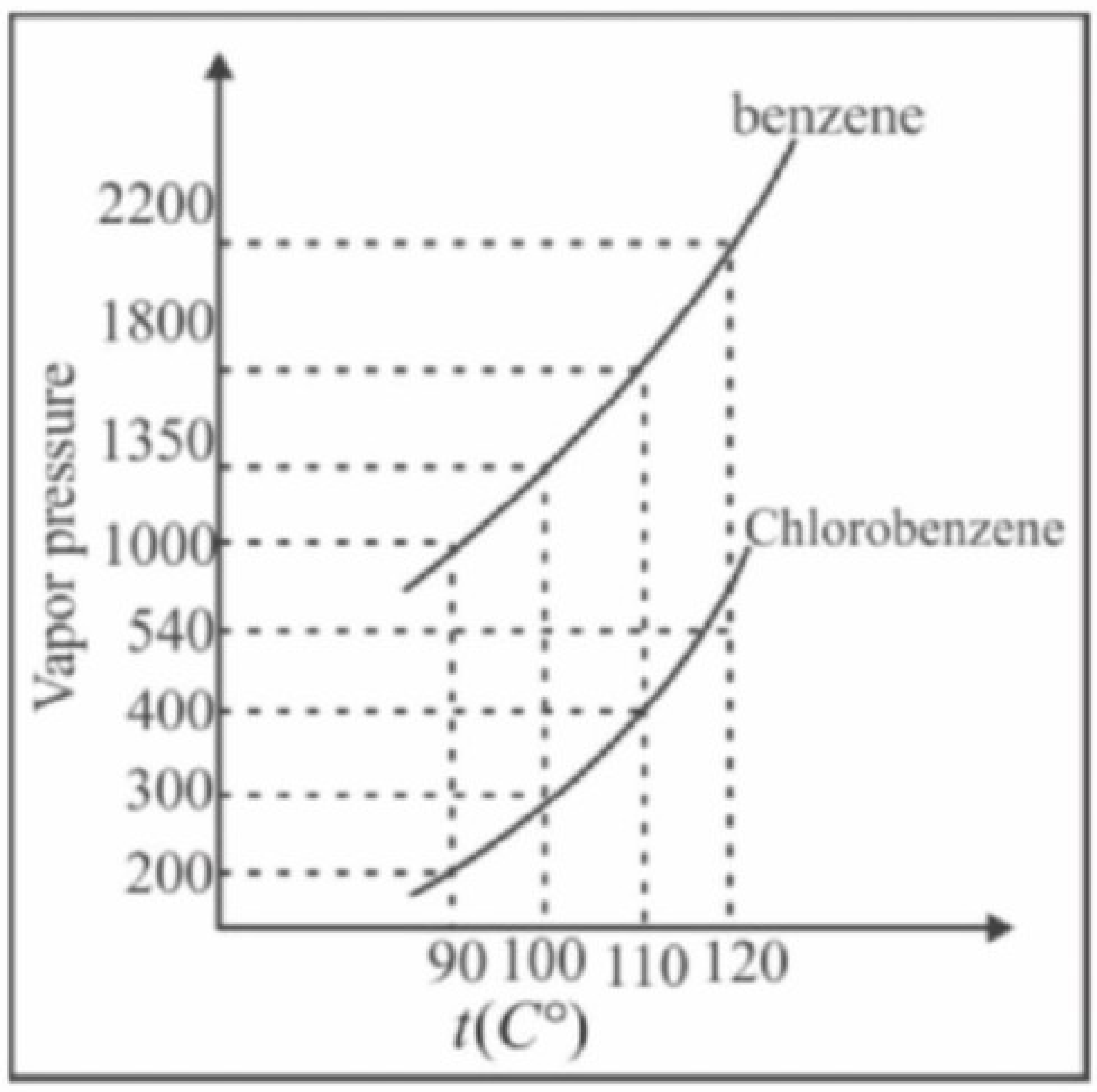
19. The solubility of common salt is 36.0 g in 100 g of water at $20°C$. If systems I, II and III contain 40.0, 36.0 and 20.0 g of the salt added to 100.0 g of water in each case, the vapour pressures would be in the order

(1) I < II < III (2) I > II > III
(3) I = II > III (4) I = II < III

20. When solid SnO_2 is added to an aqueous solution of NaOH, the

(1) vapour pressure is lowered
(2) vapour pressure is raised
(3) osmotic pressure is increased
(4) boiling point is raised.

21. Assuming the formation of an ideal solution, determine the boiling point of a mixture containing 1560 g benzene (molar mass = 78) and 1125 chlorobenzene (molar mass =112.5) using the following against an external pressure of 1000 torr.



(1) $90°C$ (2) $100°C$
(3) $110°C$ (4) $120°C$

22. A solute 'S' undergoes a reversible trimerization when dissolved in a certain solvent. The boiling point elevation of its 0.1 molal solution was found to be identical to the boiling point elevation in case of a 0.08 molal solution of a solute which neither undergoes association nor dissociation. To what percent had the solute 'S' undergone trimerization?

(1) 30% (2) 40% (3) 50% (4) 60%

23. An ideal mixture of liquids A and B with 2 mol of A and 2 mol B has a total vapor pressure of 1 atm at a certain temperature. Another mixture with 1 mol of A and 3 mol

of B has a vapor pressure greater than 1 atm. But if 4 mol of C are added to the second mixture, the vapor pressure come down to 1 atm. Vapor pressure of C, $P_C^o = 8$ atm. Calculate the vapor pressure of pure A and pure B.

(1) $P_A^o = 1.4\,atm, P_B^o = 0.7\,atm$

(2) $P_A^o = 1.2\,atm, P_B^o = 0.6\,atm$

(3) $P_A^o = 1.4\,atm, P_B^o = 0.6\,atm$

(4) $P_A^o = 0.6\,atm, P_B^o = 1.4\,atm$

24. The vapour pressures of two pure liquids A and B that form an ideal solution are 100 and 900 torr, respectively, at temperature T. This liquid solution of A and B is composed of 1 mol of A and 1 mol of B. What will be the pressure, when 1 mol of mixture has been vaporized?

(1) 800 torr (2) 500 torr
(3) 300 torr (4) 1200 torr

25. The boiling point of water $(100°C)$ becomes $100.52°C$ if 3 g of a nonvolatile solute is dissolved in 200 g of water. The molecular weight of solute is: (K_b for water is $0.6\,K\,molal^{-1}$)

(1) 12.1 g/mol (2) 15.4 g/mol
(3) 17.3 g/mol (4) 20.4 g/mol

26. Three solutions are prepared by adding 'w' gram of 'A' into 1 kg of water, 'w' gram of 'B' into another 1 kg of water and 'w' gram of 'C' in another 1 kg of water (A, B, C are non-electrolyte). Dry air is passed from these solutions in sequence $(A \rightarrow B \rightarrow C)$. The loss in weight of solution A was found to be 2g, while solution B gained 0.5 g and solution C lost 1 g. Then the relative between molar masses of A, B and C are

(1) $M_A : M_B : M_C = 4:3:5$

(2) $M_A : M_B : M_C = \frac{1}{4}:\frac{1}{3}:\frac{1}{5}$

(3) $M_C > M_A > M_B$

(4) $M_B > M_A > M_C$

27. A solution of x moles of sucrose in 100 g of water freezes at $-0.2°C$. As ice separates the freezing point goes down to $0.25°C$. How many grams of ice would have separated?

(1) 18 g (2) 20 g (3) 25 g (4) 23 g

28. 2 g of benzoic acid dissolved in 25 g C_6H_6 shows a depression in freezing point equal to 1.62 K. K_f for C_6H_6 is 4.9 K molality^{-1}. If acid forms dimer molecule in solution, then the percentage association of acid is

(1) 90.2% (2) 99.2% (3) 9.8% (4) 0.8%

29. The values of observed and calculated molecular weights of silver nitrate are 92.64 and 170, respectively. The degree of dissociation of silver nitrate is

(1) 60% (2) 83.5% (3) 46.7% (4) 60.23%

30. The vapour pressure of methanol at certain temperature is 1 atm. By adding a small amount of ethyl acetate the vapour pressure of the solution is found to be 684 mm. The relative lowering of vapour pressure is

(1) 0.1 (2) 0.9 (3) 76 (4) 0.694

31. For the experimental determination of the molecular weight of a solute by elevation of boiling point method, it is convenient to use a solvent with

(1) a low value of K_b

(2) low molecular weight

(3) a high value of K_b

(4) high molecular weight

32. An aqueous solution freezes at -0.36^0C. K_f and K_b for water are 1.8 and 0.52 respectively then value of boiling point of solution at 1 atm pressure is

(1) 101.04^0C (2) 100.104^0C
(3) 0.104^0C (4) 100^0C

33. The freezing point of equilibrium solution in aqueous medium will be the highest for

(1) $C_6H_5NH_3Cl$ (2) $C_6H_{12}O_6$
(3) $La(NO_3)_3$ (4) $Ca(NO_3)_2$

34. An aqueous solution freezes at -0.186°C

$(k_f = 1.86K\ kg\ //mol, k_b = 0.512K\ kg\ /\ mol)$.
What is the elevation in boiling point?
(1) 0.186 (2) 0.512
(3) $\frac{0.512}{1.86}$ (4) 0.0512

35. Which statement is incorrect about osmotic pressure (π), volume(V) & temperature(T)?
(1) $\pi \propto \frac{1}{V}$, if T is constant.
(2) $\pi \propto$ T, if V is constant.
(3) $\pi \propto$ V, if T is constant.
(4) π V is constant, if T is constant

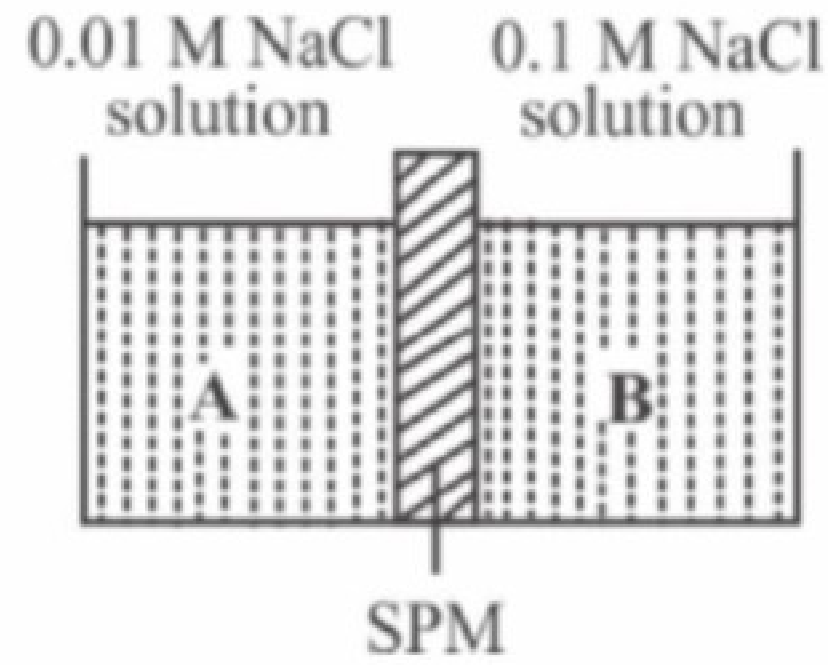
36. The van't Hoff factor 'i' for the species $[Fe(H_2O)_2(CN)_2Cl_2]NO_3.2H_2O$ is
(1) 2 (2) 3 (3) 4 (4) 5

37. Osmotic pressure of 0.1M aqueous solution of $MgCl_2$ at 300K is 4.92 atm. What will be the percentage ionisation of the salt?
(1) 79% (2) 59% (3) 49% (4) 69%

38. A 1.2% solution of NaCl is isotonic with 7.2% solution of glucose. The Van'f Hoff factor of NaCl is
(1) 1 (2) 1.95 (3) 2 (4) 2.22

39. Formation of a solution from two components can be considered as
(i) pure solvent $\rightarrow$ separated solvent molecules, ΔH_1
(ii) pure solute $\rightarrow$ separated solute molecules, ΔH_2
(iii) separated solvent and solute molecules $\rightarrow$ solution, ΔH_3.
Solution so formed will be ideal if
(1) $\Delta H_{soln} = \Delta H_1 - \Delta H_2 - \Delta H_3$
(2) $\Delta H_{soln} = \Delta H_3 - \Delta H_1 - \Delta H_2$
(3) $\Delta H_{soln} = \Delta H_1 + \Delta H_2 + \Delta H_3$
(4) $\Delta H_{soln} = \Delta H_1 + \Delta H_2 - \Delta H_3$

40. Two solutions marked as A and B are separated through semipermeable membrane as below. The phenomenon undergoing



(1) Na^+ moves from solution A to solution B
(2) Both Na^+ and Cl^- moves from solution (A) to solution (B)
(3) Both Na^+ and Cl^- moves from solution (B) to (A)
(4) Solvent molecules moves from solution (A) to (B)

41. A solution is prepared by dissolving 1.08 g of human serum albumin. A protein obtained from blood plasma in 50 c.c of aqueous solution. The solution has an osmotic pressure of 5.85 mm of Hg at 298 K . What is the molar mass of albumin?
(1) 686.55 g/mole (2) 68655 g/ mole
(3) 34328 g/ mole (4) 343.28 g/mole

42. Repeated measurements of boiling points of separate solutions of 2.36 g mercurous chloride in 100 g of water produced ΔT_b values in the range of 0.024 to 0.026 K. The atomic weights of mercury and chlorine are 200 and 35.5 respectively. K_b = 0.5 K kg/mol for water. These data suggest that mercurous chloride functions as a/an
(1) Covalent compound in aqueous medium
(2) Ionic compound in aqueous medium
(3) Reducing agent in aqueous medium
(4) Oxidising agent in aqueous medium

43. Freezing point of the following equilibrium, liquid solvent $\rightleftharpoons$ solid solvent is:
(1) $\frac{\Delta H - \Delta G}{T\Delta S}$ (2) $\frac{\Delta H}{\Delta S}$
(3) $\frac{\Delta G}{\Delta S}$ (4) $\frac{\Delta S}{\Delta H}$

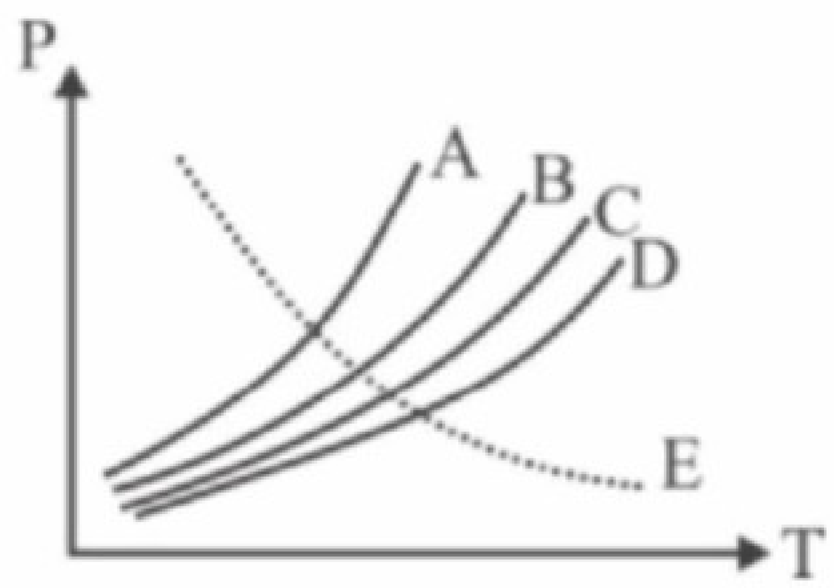
44. Consider the following statements

1. Isotonic solutions have the same molar concentration at a given temperature
2. The molal elevation constat K_b is a characteristic of a solvent, and is independent of the solute added
3. The freezing point of a 0.1 M aqueous KCl solution is more than that of a 0.1M aqueous $AlCl_3$ solution

Which of these statements is correct?

(1) 1 and 2 (2) 2 and 3
(3) 1 and 3 (4) 1, 2 and 3

45. Vapour pressure diagram of some liquids plotted against temperature are shown below



Most volatile liquid is

(1) A (2) B
(3) C (4) D

46. If the various terms in the given below expressions have usual meanings, the van't Hoff factor(i) cannot be calculated by which one of the following expressions?

(1) $\pi V = \sqrt{i}nRT$

(2) $\Delta T_f = iK_f.m$

(3) $\Delta T_b = iK_b.m$

(4) $\dfrac{P^o_{solvent} - P_{solution}}{P^o_{solvent}} = i\left(\dfrac{n}{N+n}\right)$

47. Statement -1: If a liquid solute is more volatile than the solvent added to the solvent, the vapour pressure of the solution may increse i.e., $p_s > p°$.

Statement -2: In the pressence of a more volatile liquid solute, only the solute will form the vapours and solvent will not.

(1) Statement-1and 2 are true, statement-2 is correct explanation for statement-1
(2) Statement-1and 2 are true, statement-2 is not correct explanation for statement-1
(3) Statement-1 is false, statement-2 is true
(4) Statement-1 is true, statement-2 is false

48. Which of the following solution in water possesses the highest value of elevation in Boiling point?

(1) 0.1 M NaCl (2) 0.1 M $BaCl_2$
(3) 0.1 M KCl (4) None of these

49. Statement -1: Molecular mass of benzoic acid in benzene when determined by colligative properties is found high.

Statement -2: Benzoic acid dimerises in benzene.

(1) Statement-1and 2 are true, statement-2 is correct explanation for statement-1
(2) Statement-1and 2 are true, statement-2 is not correct explanation for statement-1
(3) Statement-1 is false, statement-2 is true
(4) Statement-1 is true, statement-2 is false

ANSWER KEY

1. 4	2. 2	3. 2	4. 4	5. 2
6. 2	7. 2	8. 1	9. 4	10. 4
11. 3	12. 4	13. 4	14. 2	15. 1
16. 3	17. 4	18. 4	19. 1	20. 4
21. 2	22. 1	23. 4	24. 3	25. 3
26. 3	27. 2	28. 2	29. 2	30. 1
31. 2	32. 2	33. 2	34. 4	35. 3
36. 1	37. 3	38. 2	39. 3	40. 4
41. 2	42. 1	43. 2	44. 4	45. 1
46. 1	47. 4	48. 2	49. 1	

HINTS & SOLUTIONS

1.Sol: Conceptual

2.Sol: Molality $= \dfrac{w_2}{MW_2} \times \dfrac{1000}{Wt\ of\ solvent\ in\ grams}$

3.Sol: $[Cl^-] = \dfrac{[(20\times 0.5)+(6.6\times 20\times 2)]}{40} = 6.85M$

4.Sol: Volume of solution $= \dfrac{Mass}{Density} = \dfrac{100}{0.6} mL$

Number of equivalent of solute $= \frac{35}{35} = 1$

$$N = \frac{1\times1000}{100/0.6} = 6$$

5.Sol: $M = \frac{W_2}{MW_2}\times\frac{1000}{V(ml)}$

6.Sol: Molarity $= \frac{\%\times10\times d}{MW_2} = \frac{22\times10\times1.253}{342}$

$$= 0.805M$$

$$\text{Normality} = \frac{\%\times10\times d}{EW_2} = \frac{22\times10\times1.253}{342/6} = 4.83N$$

$$\text{Molality} = \frac{22\times1000}{342(100-22)} = 0.825\ m$$

7.Sol: Higher is the K_H value, lower is the solubility.

8.Sol: Henry's law is m = K.P; where m is the mass of gas absorbed by given volume of the solvent and P is the pressure of gas:

$\therefore\ \log m = \log K + \log P$

9.Sol: In the figure, pressure increases over the solution phase by compressing the gas to a smaller volume. This will increase the number of gaseous particle per unit volume over the solution and also the rate at which the gaseous particles are striking the surface of solution to enter it.

10.Sol: For the ideal solution, $\Delta H = 0, \Delta V = 0$ (for mixture)

11.Sol: Conceptual

12.Sol: Conceptual

13.Sol: If two liquids A and B form minimum boiling azeotrope at some specific composition then A - B interactions are weaker than those of A - A and B - B. It is due to the fact that in case of positive deviation, we get minimum boiling azeotropes.

14.Sol: $X_A = \frac{n_A}{(n_A+n_B)} = \frac{3}{5} = 0.6$

$X_B = 0.4$

$P = P_A^oX_A + P_B^oX_B$

$184 = 200\times0.6 + P_B^o\times0.4$

$P_A^o = 160$ torr

15.Sol: Conceptual

16.Sol: Conceptual

17.Sol: +ve deviation

18.Sol: $P = P_A^o x_A + P_B^o x_B = P_A^o + x_B\left(P_B^o - P_A^o\right)$

$$[\because x_A = 1 - x_B]$$

19.Sol: Solution is cases I and II are saturated and that in III is unsaturated.

20.Sol:

$$2Na^+(aq) + 2OH^-(aq) + SnO_2(s) \rightarrow 2Na^+(Aq) + SnO_3^{2-}(aq) + H_2O$$

The number of ions decreases in the ratio of 4 to 3, and so also the colligative property.

21.Sol: P_T (at $100°C) = \frac{2}{3}\times1350 + \frac{1}{3}\times300$

$$= 900 + 100 = 1000\ torr$$

22.Sol:

$$3S \rightleftharpoons S_3$$

1	0
$1-\alpha$	$\frac{\alpha}{3}$

$$\Rightarrow\ i = 1 - \frac{2\alpha}{3}$$

Now $0.1\left(1-\frac{2\alpha}{3}\right) = 0.08$

$\Rightarrow\ \alpha = 0.3.$ Hence, 30% trimerization.

23.Sol: $\frac{P_A^o}{2} + \frac{P_B^o}{2} = 1\,atm$

$\Rightarrow\ P_A^o + P_B^o = 2\,atm$

$\frac{P_A^o}{4} + \frac{3P_B^o}{4} > 1\,atm$

$\Rightarrow\ P_A^o + 3P_B^o > 4\,atm$

and $\frac{P_A^o}{8} + \frac{3P_B^o}{8} + \frac{4P_C^o}{8} = 1\,atm$

$\Rightarrow\ P_A^o + 3P_B^o + 4P_C^o = 8\,atm$

So $P_A^o + 3P_B^o = (8 - 4\times0.8)atm = 4.8\,atm$

Hence, $P_B^o = 1.4\,atm$

$P_A^o = 0.6\,atm$

24.Sol: Let n_B mole of B present in 1 mol of mixture that has been vaporized. Thus,

$y_B = n_B / 1$.

Mole fraction of B in the remaining liquid phase is given by

$$x_B = \frac{1-n_B}{1}$$

$$x_B = \frac{p - p_A^o}{p_B - p_A^o} \quad \text{(i)}$$

$[\because \; p = p_T^o + (p_B^o - p_T^o)x_B]$

and $$y_B = \frac{p_B}{p} \Rightarrow \frac{p_B^o x_B}{p} \quad \text{(ii)}$$

After substitution of values of x_B and y_B in Eqs. (i) and (ii), we get

$$1 - n_B = \frac{p - p_T^o}{p_B^o - p_T^o} \quad \text{(iii)}$$

and $$n_B = \frac{(1-n_B)p_B^o}{p} \quad \text{(iv)}$$

or $$n_B = \frac{p_B^o}{p + p_B}$$

so, $$1 - \frac{p_B^o}{p + p_B} = \frac{p - p_T^o}{p_B^o - p_T^o}$$

$\Rightarrow \; p = \sqrt{p_B^o - p_T^o} = \sqrt{100 \times 900}$

$\Rightarrow$ 300 torr

25.Sol: First boiling point of water $= 100°C = T_b^o$

Final boiling point of water $= 100.52°C = T_b$

$w = 3g, W = 200g, K_b = 0.6\,K\,kg\,mol^{-1}$

$\Delta T_b = 100.52 - 100 = 0.52°C$

$$M_{solute} = \frac{K_b \times w_{solvent} \times 1000}{\Delta T_b \times W_{solvent}} = \frac{0.6 \times 3 \times 1000}{0.52 \times 200}$$

$$= \frac{1800}{104} = 17.3\,g/mol$$

26.Sol: The loss in water should be proportional to vapor pressure above that solution

So, $P_{S_A} \propto 2g \quad P_{S_B} \propto 1.5g \quad P_{S_C} \propto 2.5g$

So, maximum vapor pressure is above C solution; hence it is having minimum lowering and hence minimum mole fraction (hence minimum number of moles of solute). So, maximum molar mass of a substance.

27.Sol: $$(\text{molality})_i = \frac{x \times 1000}{100} = 10x = 0.2 \times K_b$$

$$(\text{molality})_f = \frac{x \times 1000}{w} = 0.25 \times K_b$$

So $$\frac{0.2}{0.25} = \frac{w}{100}$$

$\Rightarrow$ So, $w = 80\,g$

Hence, ice separated = 20 g

28.Sol: $$\Delta T = \frac{1000 \times K_f \times w}{m \times W}$$

$$= \frac{1000 \times 4.9 \times 2}{122 \times 25} = 3.213K$$

$$i = \frac{\Delta T_{exp.}}{\Delta T_{cal}} = 1 - \alpha + \frac{\alpha}{n}$$

$$\therefore \; \frac{1.62}{3.12} = 1 - \alpha + \frac{\alpha}{2}$$

$\therefore \; \alpha = 0.992$ or 99.2%

29.Sol: i for

$$AgNO_3 = \frac{\text{Normal molecular weight}}{\text{Observed molecular weight}} = 1 + \alpha$$

$$\alpha = \frac{170}{92.64} - 1 = 0.835 = 83.5\%$$

30.Sol: Relative lowering of vapour pressure

$$= \frac{P^0 - P}{P^0}$$

31.Sol: Conceptual

32.Sol: $(\Delta T_f)/(\Delta T_b) = K_f / K_b$

$$0.36/\Delta T_b = 1.8/0.52$$

$$\Delta T_b = 0.104$$

$$T_b = 100.104°C$$

33.Sol: Glucose does not dissociate in water, hence the freezing point depression of glucose solution will be lowest. Thus, the freezing point of glucose solution will be the highest.

$$\left(i \propto \frac{1}{F.P.}\right)$$

34.Sol: $(\Delta T_f)/(\Delta T_b) = K_f / K_b$

$$0.186/\Delta T_b = 1.8/0.52$$

$$\Delta T_b = 0.0512$$

35.Sol: $\pi V = nST$

36.Sol: Number of ions produced from the complex is 2 i.e., $[Fe(H_2O)_2(CN)_2Cl_2]^+$ and NO_3^-, so i = 2

37.Sol: $\pi = iCST$

$$4.92 = i \times 0.1 \times 0.0821 \times 300$$

$$i = 1.99$$

$$\alpha = \frac{i-1}{n-1} = \frac{1.99-1}{3-1} = \frac{0.99}{2} = 0.49$$

Percentage of ionization=49%

38.Sol: $\pi_{(\mathrm{NaCl})} = \pi_{(\mathrm{Glucose})}$

$$iC_1ST = C_2ST$$

$$iC_1 = C_2$$

$$i(1.2/58.5) = (7.2/180)$$

$$i = 1.95$$

39.Sol: If net ΔH_{soln} is the sum of three steps, this means that solute-solvent interactions are similar to solvent - solvent and solute - solute interactions.

40.Sol: Only solvent particles move from A to B i.e., dilute solution to concentrated solution through a semipermeable membrane.

41.Sol: Molecular weight $= W \times \frac{R \times T}{\pi \times V}$

42.Sol: Conceptual

43.Sol: $T_f = \frac{\Delta H}{\Delta S}$

44.Sol: Conceptual

45.Sol: Conceptual

46.Sol: Van't Hoff equation is

$$\pi V = inRT$$

For depression in freezing point.

$$\Delta T_f = i \times K_f \times m$$

For elevation in boiling point.

$$\Delta T_b = i \times K_b \times m$$

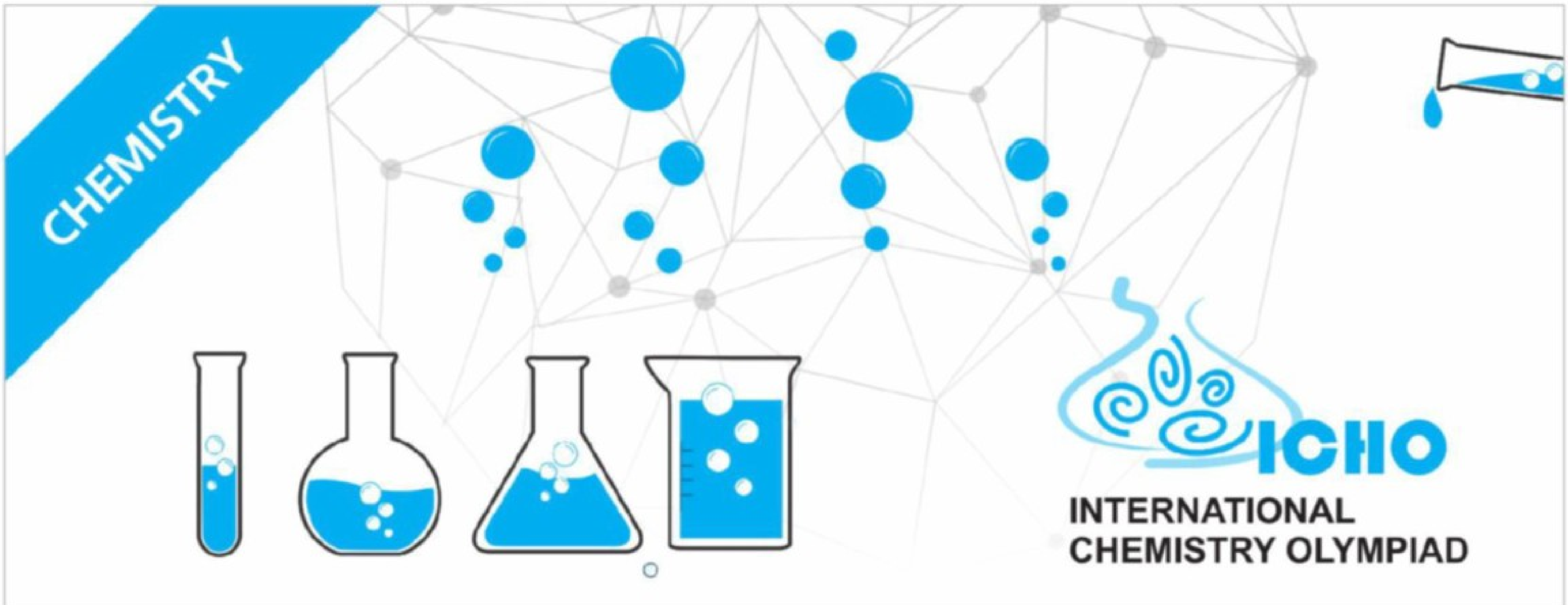
For lowering of vapor pressure,

$$\frac{P^o_{solvent} - P_{solution}}{P^o_{solvent}} = i\left(\frac{n}{N+n}\right).$$

47.Sol: Both the solute and solvent will form the vapour but vapour phase will become richer in the more volatile component.

48.Sol: $BaCl_2$ gives maximum (3) ions hence it shows highest elevation in boiling point.

49.Sol: Colligative properties are the properties of solutions containing non volatile solute. It is correct that molecular mass of bonzoic and when determined by colligative properties is found abnormally high. This is because dimerisation of benzoic acid in benzene takes place in solution resulting high molecular mass. Therefore, statement 1 and statement 2 are true and statement 2 is correct explanation.



[2011-12]

1. Bromine can be liberated from KBr Solution by the action of
   (a) Iodine Solution (b) Chlorine water
   (c) NaCl (d) KI
2. Oxygen exhibits (-1) oxidation state in
   (a) OF_2 (b) H_2O (c) H_2O_2 (d) HClO
3. The compound has both ionic and covalent bonds is
   (a) Boric acid (H_3BO_3)
   (b) Sodium chloride (NaCl)
   (c) Ethyl alcohol (C_2H_5OH)
   (d) Sodium phenolate (C_6H_5ONa)
4. The metal that dissolves in liquid ammonia giving dark blue coloured solution is
   (a) Sn (b) Pb (c) Na (d) Ag
5. Hydrogen fluoride is a liquid at room temperature due to
   (a) dimerisation
   (b) dissociation followed by aggregation
   (c) association
   (d) polymerisation
6. Which of the following hydroxides is NOT an alkali?
   (a) Ammonium hydroxide
   (b) Calcium hydroxide
   (c) Copper hydroxide
   (d) Sodium hydroxide
7. The most basic oxide among MnO, Mn_2O_3 MnO_2 and Mn_2O_7 is
   (a) MnO (b) MnO_2 (c) Mn_2O_3 (d) Mn_2O_7
8. The metal which cannot displace hydrogen from acid is
   (a) Silver (b) Sodium
   (c) Calcium (d) Magnesium
9. Sudden decrease in the intermolecular forces of attraction occurs most efficiently in
   (a) evaporation (b) melting
   (c) condensation (d) sublimation
10. Correct formula of dolomite is
    (a) $CaCO_3$. $MgCO_3$ (b) $CaCO_3$. $ZnCO_3$
    (c) $MgCO_3$.$ZnCO_3$ (d) $FeCO_3$.$CaCO_3$
11. The compound used to remove carbon dioxide from air is
    (a) Sodium carbonate
    (b) Sodium hydroxide
    (c) Sodium chloride
    (d) Sodium sulphate
12. The property which is characteristic of an electrovalent compound is that
    (a) it is easily vaporized
    (b) it has a high melting point
    (c) it is a weak electrolyte
    (d) it often exists as a liquid
13. Out of the following , the correct activity series of the metals is
    (a) K > Na > Ca > Mg
    (b) Na > K > Ca > Mg
    (c) Mg > Ca > Na > K
    (d) Mg > Ca > K > Na
14. Which of the following group elements form electron deficient molecules?
    (a) Group IV (b) Group V
    (c) Group III (d) Group I
15. Which of the following elements forms polyatomic molecules?

(a) Nitrogen (b) Chlorine
(c) Argon (d) Boron

16. Mixture of ethyl alcohol and water can be easily separated by using
(a) Separating funnel (b) Fractional distillation
(c) Filter paper (d) None of the above

17. Pressure of a certain volume V of an ideal gas is increased by five times of its initial pressure whereas the temperature is reduced to 50% of its initial temperature. The resulting volume of the gas is
(a) 10V (b) 0.1V (c) 0.5V (d) 0.25V

18. The release of chemical messenger at nerve-muscle end plate is under the influence of the ions
(a) Cl^- (b) Fe^{++} and Sr^{++}
(c) Ca^{++} (d) Mg^{++} and Sr^{++}

[2012-13]

1. Charring of sugar in concentrated sulphuric acid is due to
(a) Oxidation of sugar (b) Reduction of sugar
(c) Hydrolysis of sugar
(d) Dehydration of sugar

2. A radioactive element ${}_{90}R^{232}$ emits one alpha (α) particle and then two beta (β) particles. The daughter will have
(a) Atomic no. 90, Mass no. 228
(b) Atomic no. 90, Mass no. 232
(c) Atomic no. 88, Mass no. 228
(d) Atomic no. 88, Mass no. 232

3. The equilibrium constant for the gaseous reaction $N_2 + O_2 \rightleftharpoons 2NO$ is K. The equilibrium constant for the formation of one mole of NO will be
(a) K/2 (b) K (c) 2K (d) $\sqrt{K}$

4. The solubility of a salt B_2D_3 is X mole L^{-1}. Its solubility product is
(a) X^5 (b) $6X^5$ (c) $36X^5$ (d) $108X^5$

5. 8 grams of oxygen at NTP contain
(a) 1.5×10^{23} molecules
(b) 3.0×10^{23} molecules
(c) 6.023×10^{23} molecules
(d) 1.5×10^{20} molecules

6. When 1 g of $CaCO_3$ reacts with 50 ml of 0.1 M HCl, the volume of CO_2 produced is
(a) 11.2 mL (b) 22.4 mL
(c) 112 mL (d) 224 mL

7. When a dilute solution of sulphuric acid is electrolysed using platinum electrodes the gas evolved at the positive electrode is
(a) SO_2 (b) SO_3 (c) H_2 (d) O_2

8. If equal weights of oxygen and nitrogen are kept in seperated containers at the same temperature then
(a) Both the containers have the same number of molecules
(b) More molecules are present in the oxygen container
(c) The pressure of the nitrogen container is greater than that of the oxygen container
(d) The pressure of the oxygen container is greater than that of nitrogen container

9. The element with electronic configuration $1s^2, 2s^2, 2p^6, 3s^2$ is a/an
(a) Metal (b) Non-Metal
(c) Metalloid (d) Inert gas

10. The compound which contains both ionic and covalent bonds is
(a) KCl (b) CS_2 (c) C_2H_6 (d) KCN

11. Molality of a solution is the number of
(a) moles of the solute per 1000 mL of the solution.
(b) moles of the solute per 1000 mL of the solvent.
(c) moles of the solute per 1000g of the solvent.
(d) moles of the solute per 100g of the solvent.

12. The pH of blood is maintained within the range 7.36-7.42 by
(a) CH_3COONH_4
(b) CH_3COONa / CH_3COOH
(c) HCO_3^- / CO_3^{2-} (d) CH_3COOH

13. An alkaline solution of K_2HgI_4 is called
(a) Fehling's reagent (b) Benedict's reagent
(c) Nessler's reagent (d) Tollen's reagent

14. At constant temperature and pressure which of the following statement is true for the reaction.

$$CO_2(g)+\frac{1}{2}O_2(g)\rightarrow CO_2(g)$$

(a) $\Delta E=\Delta H$ (b) $\Delta E>\Delta H$

(c) $\Delta E<\Delta H$

(d) ΔH and ΔE are independent of each other

15. The green coloured substance produced during the burning of ammonium dichromate in fireworks is

(a) CrO_3 (b) Cr_2O_3

(c) $CrO(O_2)_2$ (d) $Cr(OH)_3$

16. The oxidation number of chlorine in $CaOCl_2$ is

(a) 0 (b) -1 (c) +1 (d) +3

17. Green house effect is related to

(a) Ozone layer depletion

(b) Carbon dioxide emission and absorption

(c) Nitrogen radiation (d) Oxygen radiation

ANSWER KEY

[2011-12]

1. b	**2.** c	**3.** d	**4.** c	**5.** c
6. c	**7.** a	**8.** a	**9.** d	**10.** a
11. b	**12.** b	**13.** a	**14.** c	**15.** d
16. b	**17.** b	**18.** c		

[2012-13]

1. d	**2.** a	**3.** d	**4.** d
5. a	**6.** Bonus	**7.** d	**8.** c
9. a	**10.** d	**11.** c	**12.** c
13. c	**14.** b	**15.** b	**16.** a
17. b			

HINTS & SOLUTIONS

[2011-12]

1.Sol: $KBr(aq)+Cl_2(aq)\rightarrow KCl(aq)+Br_2(aq)$

More reactive non-metal displaces less reactive non-metal from its salt solution. (Top element displaces bottom element in halogens)

2.Sol: (c) Oxygen exhibits (-1) oxidation state in peroxides, (-2) in water and hypochlorous acid and (+2) in oxygen difluoride.

3.Sol: Boric acid (H_3BO_3) and ethyl alcohol (C_2H_5OH) both contain covalent bonds.

Sodium chloride $(NaCl)$ contains ionic bond.

Sodium phenolate (C_6H_5ONa) contains both covalent and ionic bonds only.

4.Sol (c) Sodium dissolves in liquid ammonia giving dark blue coloured solution. (due to solvated electrons)

5.Sol: Hydrogen fluoride is a liquid at room temperature due to association of HF molecules through Inter molecular H -bonding.

6.Sol: Ammonium hydroxide, calcium hydroxide and sodium hydroxide are soluble in water. Copper hydroxide gives pale blue precipitate in water.

7.Sol: MnO is most basic oxide among MnO, Mn_2O_3, MnO_2 and Mn_2O_7. The basic nature of the oxides decreases as the oxidation state increases.

8.Sol: Silver metal cannot displace hydrogen from dilute acid as it is less reactive than hydrogen.

9.Sol: In sublimation, solid changes directly into gaseous state. Hence sudden decrease in the intermolecular forces of attraction occurs most efficiently.

10.Sol: Conceptual

11.Sol: Sodium hydroxide reacts with CO_2 and forms sodium carbonate.

$$2NaOH(aq)+CO_2(g)\longrightarrow Na_2CO_3(aq)+H_2O$$

12.Sol: Due to strong electrostatic force of attraction in electrovalent compounds they have hight melting points.

13.Sol: Conceptual

14.Sol: Group III elements B, A1 etc. shares three electrons with atoms of other elements. They are two electrons short to complete their octet. Hence they are electron deficient molecules.

15.Sol: Nitrogen and chlorine forms diatomic molecules. Argon is monoatomic. Boron forms polyatomic molecules.

16.Sol: Ethyl alcohol and water gave very less difference in their boiling points, So they can be easily separated by using fractional distillation

17.Sol: Let the initial pressure, Temperature and volume of gas are P_1, T_1, V_1.

Then $P_2 = 5P_1$, $T_2 = T_2 = \frac{T_1}{2}$ and $V_2 = ?$

$$\therefore \frac{P_1V_1}{T_1} = \frac{5P_1 \times V_2}{T_1/2}$$

$$V_2 = \frac{V_1}{10} = 0.1\,V_1$$

18.Sol: Conceptual

[2012-13]

1. $C_{12}H_{22}O_{11} \xrightarrow[\text{(dehydration)}]{\text{Con.}H_2SO_4} \underset{\text{Charcoal}}{12C} + 11H_2O$

2.Sol: ${}^{232}_{90}R \xrightarrow{-\alpha} {}^{228}_{88}X \xrightarrow{-2\beta} {}^{228}_{90}Y$

3.Sol: $\because$ 2 mole = K

$\therefore$ 1 mole = $\sqrt{K}$

4.Sol: $B_2D_3 \rightleftharpoons 2B^{3+} + 3D^{2-}$

(Let solubility = X) $\quad$ 2X $\quad$ 3X

$$K_{sp} = [B^{3+}]^2[D^{2-}]^3$$

$$= [2X]^2[3X]^3$$

$$= 4X^2 \times 27X^3$$

$$= 108X^5$$

5.Sol: $n = \frac{8}{32}$

$= \frac{1}{4}$

$\because$ 1 mole = 6.023×10^{23} molecule

$\therefore 1/4\,\text{mole} = 6.023 \times 10^{23} \times \frac{1}{4}$

$= 1.5 \times 10^{23}$ molecules

6.Sol: $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$

$\frac{1}{100}$ mol $\quad$ $\frac{50 \times 0.1}{1000}$ mol

$\because$ Limiting reagent = HCl

$\because$ 2 mol HCl = 22.4 L CO_2

$\therefore \quad \frac{50 \times 0.1}{1000}$ mol

$= \frac{50 \times 0.1}{1000} \times \frac{22.4}{2}$ L CO_2

= 0.056 L = 56 mL

7.Sol: $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$

$2H_2O \rightleftharpoons 2H^+ + 2OH^-$

discharge potential of OH^- is less

So OH^- discharge first at positive electrode

$$2OH^- \rightarrow H_2O + \frac{1}{2}O_2 + 2e^-$$

8.Sol: Pressure is directly proportional to no. of moles.

no. of moles of $N_2 = x/28$

no. of moles of $O_2 = x/32$

$\therefore$ no. of moles of N_2 > no. of moles of O_2

9.Sol: Alkaline earth metal.

10.Sol: K^+, ${}^{\ominus}C \equiv N$

11.Sol: Definition

12.Sol: Conceptual

13.Sol: Nessler's reagent

14.Sol: $\Delta H = \Delta E + \Delta nRT$

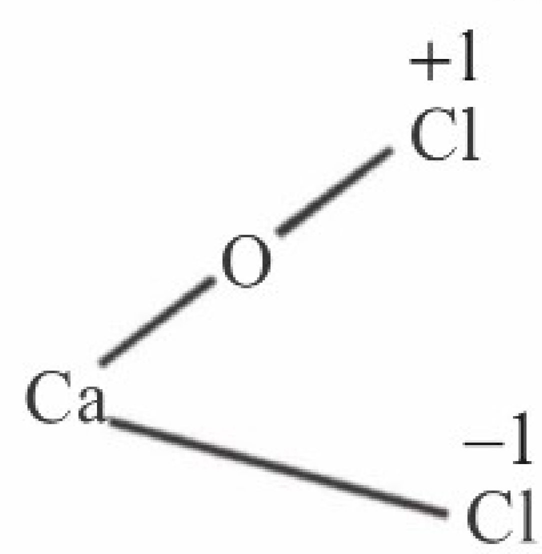
Here $\Delta n = 1 - 1.5 = -0.5$

$\therefore \quad \Delta H = \Delta E - 0.5RT$

$\therefore \quad \Delta E > \Delta H$

15.Sol: $(NH_4)_2Cr_2O_7 \rightarrow \underset{\text{green}}{Cr_2O_3} + N_2 + 4H_2O$

16.Sol:



Average O.S $= \frac{(+1)+(-1)}{2} = 0$

or

$CaOCl_2$

$2 - 2 + 2x = 0$

$2x = 0$

$x = 0$

17.Sol: Conceptual

Previous years JEE MAIN Questions

HYDROGEN AND ITS COMPOUNDS [ONLINE QUESTIONS]

1. Identify the incorrect statement regarding heavy water: **[2016]**
   (a) It reacts with SO_3 to form deuterated sulphuric acid (D_2SO_4).
   (b) It is used as a coolant in nuclear reactions
   (c) It reacts with CaC_2 to produce C_2D_2 and $Ca(OD)_2$.
   (d) It reacts with Al_4C_3 to produce CD_4 and $Al(OD)_3$.
2. Which physical property of dihydrogen is wrong? **[2015]**
   (a) Odourless gas
   (b) Tasteless gas
   (c) Colourless gas
   (d) Non-inflammable gas
3. Permanent hardness in water cannot be cured by **[2015]**
   (a) Treatment with washing soda
   (b) Boiling
   (c) Calgon's method
   (d) Ion exchange method
4. Hydrogen peroxide acts both as an oxidising and as a reducing agent depending upon the nature of the reacting species. In which of the following cases H_2O_2 acts as a reducing agent in acid medium? **[2014]**
   (a) MnO_4^- (b) $Cr_2O_7^{2-}$ (c) SO_3^{2-} (d) KI
5. The number of protons, electrons and neutrons in a molecule of heavy water are respectively: **[2013]**
   (a) 8, 10, 11 (b) 10, 10, 10
   (c) 10, 11, 10 (d) 11, 10, 10

[OFFLINE QUESTIONS]

1. Hydrogen peroxide oxidises $\left[Fe(CN)_6\right]^{4-}$ to $\left[Fe(CN)_6\right]^{3-}$ in acidic medium but reduces $\left[Fe(CN)_6\right]^{3-}$ to $\left[Fe(CN)_6\right]^{4-}$ in alkaline medium. The other products formed are, respectively: **[2018]**
   (a) (H_2O+O_2) and (H_2O+OH^-)
   (b) H_2O and (H_2O+O_2)
   (c) H_2O and (H_2O+OH^-)
   (d) (H_2O+O_2) and H_2O
2. Which one of the following statements about water is FALSE? **[2016]**
   (a) There is extensive intramolecular hydrogen bonding in the condensed phase.
   (b) Ice formed by heavy water sinks in normal water.
   (c) Water is oxidises to oxygen during photosynthesis.

(d) Water can act both as an acid and as a base.

3. From the following statements regarding H_2O_2, choose the incorrect statement **[2015]**

(a) It has to be stored in plastic or wax lined glass bottles in dark
(b) It has to be kept away from dust
(c) It can act only as an oxidising agent
(d) It decomposed on exposure to light

4. In which of the following reactions H_2O_2 acts as a reducing agent? **[2014]**

(a) $H_2O_2 + 2H^+ + 2e^- \rightarrow 2H_2O$
(b) $H_2O_2 + 2e^- \rightarrow O_2 + 2H^+$
(c) $H_2O_2 + 2e^- \rightarrow 2OH^-$
(d) $H_2O_2 + 2OH^- - 2e^- \rightarrow O_2 + 2H_2O$

5. Very pure hydrogen (99.9%) can be made by which of the following processes? **[2012]**

(a) Reaction of methane with steam
(b) Mixing natural hydrocarbons of high molecular weight
(c) Electrolysis of water
(d) Reaction of salts like hydrides with water

6. In context with the industrial preparation of hydrogen from water gas $(CO + H_2)$, which of the following is the correct statement? **[2008]**

(a) CO and H_2, are fractionally separated using differences in their densities
(b) CO is removed by absorption in aqueous Cu_2Cl_2 solution
(c) H_2 is removed through occlusion with pd
(d) CO is oxidised to CO_2 with steam in the presence of a catalyst followed by absorption of CO_2 in alkali

s-BLOCK ELEMENTS

[ONLINE QUESTIONS]

1. Which one of the following is an oxide? **[2017]**

(a) CsO_2 (b) SiO_2 (c) KO_2 (d) BaO_2

2. The correct order of the solubility of alkaline-earth metal sulphates in water is **[2016]**

(a) Mg > Ca > Sr > Ba
(b) Mg > Sr > Ca > Ba
(c) Mg < Ca < Sr < Ba
(d) Mg < Sr < Ca < Ba

3. The commercial name for calcium oxide is : **[2015]**

(a) Quick lime (b) Milk of lime
(c) Slaked lime (d) Limestone

4. Which of the alkaline earth metal halides given below is essentially covalent in nature? **[2015]**

(a) $SrCl_2$ (b) $CaCl_2$
(c) $BaCl_2$ (d) $MgCl_2$

5. Which of the following statements about Na_2O_2 is not correct? **[2014]**

(a) It is diamagnetic in nature
(b) It is derivative of H_2O_2
(c) Na_2O_2 oxidises Cr^{3+} to CrO_4^{2-} in acid medium
(d) It is the super oxide of sodium

6. The solubility order of for alkali metal fluorides in water is : **[2013]**

(a) LiF < RbF < KF < NaF
(b) RbF <KF< NaF< LiF
(c) LiF > NaF > KF > RbF
(d) LiF<NaF < KF < RbF

[OFFLINE QUESTIONS]

1. The main oxides formed on combustion of Li, Na and K in excess of air are, respectively **[2016]**

(a) Li_2O_2, Na_2O_2 and KO_2
(b) Li_2O, Na_2O_2 and KO_2
(c) Li_2O, Na_2O and KO_2
(d) LiO_2, Na_2O_2 and K_2O

2. Which one of the following alkaline earth metal sulphates has its hydration enthalpy greater than its lattice enthalpy? **[2015]**

(a) $BaSO_4$ (b) $SrSO_4$
(c) $CaSO_4$ (d) $BeSO_4$

3. The first ionisation potential of Na is 5.1 eV. The value of electron gain enthalpy of Na^+ will be **[2013]**
(a) -2.55 eV (b) -5.1 eV
(c) -10.2 eV (d) +2.55 eV

4. Which of the following on thermal decomposition yields a basic as well as acidic oxide? **[2012]**
(a) $NaNO_3$ (b) $KClO_3$
(c) $CaCO_3$ (d) NH_4NO_3

5. What is the best description of the change that occurs when $Na_2O(s)$ is dissolved in water? **[2011]**
(a) Oxide ion accepts sharing in a pair of electrons
(b) Oxide ion donates a pair of electrons
(c) Oxidation number of oxygen increases
(d) Oxidation number of sodium decreases

6. The products obtained on heating $LiNO_3$ will be : **[2010]**
(a) $Li_2O + NO_2 + O_2$ (b) $Li_3N + O_2$
(c) $Li_2O + NO + O_2$ (d) $LiNO_3 + O_2$

p-BLOCK ELEMENTS [ONLINE QUESTIONS]

1. A group 13 element 'X' reacts with chlorine gas to produce a compund XCl_3, XCl_3 is electron deficient and easily reacts with NH_3 to form $Cl_3X \leftarrow NH_3$ adduct; however, XCl_3 does notdimerize. X is: **[2018]**
(a) B (b) Al (c) In (d) Ga

2. Identify the reaction which does not liberate hydrogen: **[2016]**
(a) Reaction of lithium hydride with B_2H_6
(b) Electrolysis of acidified water using Pt electrodes
(c) Reaction of zinc with aqueous alkali
(d) Allowing a solution of sodium in liquid ammonia to stand

3. Match the items in Column I with its main use listed in Column II **[2016]**

Column I	Column II
(A) Silica gel	(i) Transistor
(B) Silicon	(ii) Ion-exchanger
(C) Silicone	(iii) Drying agent
(D) Silicate	(iv) Sealant

(a) (A) - (iii), (B) - (i), (C) - (iv), (D) - (ii)
(b) (A) - (iv), (B) - (i), (C) - (ii), (D) - (iii)
(c) (A) - (ii), (B) - (i), (C) - (iv), (D) - (iii)
(d) (A)- (ii), (B) - (iv), (C) - (i), (D) - (iii)

4. **Assertion :** Among the carbon allotropes, diamond is an insulator, whereas, graphite is a good conductor of electricity.
Reason: Hybridization of carbon in diamond and graphite are sp^3 and sp^2, respectively. **[2016]**
(a) Both assertion and reason are correct, but the reason is not the correct explanation for the assertion
(b) Both assertion and reason are correct, and the reason is the correct explanation for the assertion
(c) Both assertion and reason are incorrect
(d) Assertion is incorrect statement, but the reason is correct.

5. In the following sets of reactants which two sets best exhibit the amphoteric character of Al_2O_3, xH_2O ? **[2014]**
Set 1: Al_2O_3. x$H_2O(s)$ and OH^- (aq)
Set 2: Al_2O_3. x$H_2O(s)$ and $H_2O(l)$
Set 3: Al_2O_3.x$H_2O(s)$ and NH_3 (aq)
(a) 1 and 2 (b) 1 and 3
(c) 2 and 4 (d) 3 and 4

6. The gas evolved on heating CaF_2 and SiO_2 with concentrated H_2SO_4, on hydrolysis gives a white gelatinous precipitate. The precipitate is: **[2014]**
(a) Hydrofluorosilicic acid
(b) Silica acid
(c) Silicic acid
(d) Calciumfluorosilicate

7. Example of a three-dimensional silicate is: **[2014]**

(a) Zeolites (b) Ultramarines
(c) Feldspars (d) Beryls

8. Identify the incorrect statement: **[2013]**
(a) In $(Si_3O_9)^{6-}$, tetrahedral SiO_4 units share two oxygen atoms.
(b) Trialkylchlorosilane on hydrolysis gives R_3SiOH
(c) $SiCl_4$ undergoes hydrolysis to give H_4SiO_4
(d) $(Si_3O_9)^{6-}$ has cyclic structure

9. The catenation tendency of C, Si and Ge is in the order Ge < Si < C. The bond energies (in $kJ\ mol^{-1}$) of C-C, Si-Si and Ge-Ge bonds are respectively **[2013]**
(a) 348, 297, 260 (b) 297, 348, 260
(c) 348, 260, 297 (d) 260, 297, 348

ANSWER KEY

HYDROGEN AND ITS COMPOUNDS [ONLINE QUESTIONS]

1. b **2.** d **3.** b **4.** a **5.** b

[OFFLINE QUESTIONS]

1. b **2.** a **3.** c **4.** d **5.** d
6. d

s-BLOCK ELEMENTS [ONLINE QUESTIONS]

1. b **2.** a **3.** a **4.** d **5.** d
6. d

[OFFLINE QUESTIONS]

1. b **2.** d **3.** b **4.** c **5.** b
6. a

p-BLOCK ELEMENTS [ONLINE QUESTIONS]

1. a **2.** a **3.** a **4.** b **5.** b
6. d **7.** c **8.** b **9.** a

HINTS & SOLUTIONS

HYDROGEN AND ITS COMPOUNDS [ONLINE QUESTIONS]

1.Sol: Heavy water acts as moderator. This is used in nuclear reactors to slow down the speed of fast moving neutrons.

2.Sol: H_2 is a highly inflammable gas.

3.Sol: Only temporary hardness which is due to HCO_3^- (bicarbonate) ions is removed by boiling.

4.Sol: H_2O_2 acts as a reducing agent only in presence of strong oxidising agents (i.e., MnO_4^-) in acidic as well as alkaline medium.

$$2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \rightarrow K_2SO_4 + 8H_2O + 5O_2$$

5.Sol: Heavy water is D_2O hence,
number of electrons $= 2 + 8 = 10$
number of protons = 10
Atomicmass of $D_2O = 4 + 16 = 20$
hence number of neutron
= Atomic mass - number of protons
$= 20 - 10 = 10$

[OFFLINE QUESTIONS]

1.Sol: (i)
$$\left[Fe^{+2}(CN)_6\right]^{4-} + H_2O_2^{-1} + 2H^+$$
$$\downarrow$$
$$\left[Fe^{+3}(CN)_6\right]^{3-} + 2H_2O^{-2}$$

(ii) $\left[Fe^{+3}(CN)_6\right]^{3-} + H_2O_2^{-1} + 2OH^-$
$$\downarrow$$
$$\left[Fe^{+2}(CN)_6\right]^{4-} + O_2^{0} + 2H_2O$$

2.Sol: There is extensive intermolecular hydrogen bonding in the condensed phase instead of intramolecular H-bonding.

3.Sol: H_2O_2 has oxidising and reducing properties both.

4.Sol: Conceptual

5.Sol: Very pure hydrogen can be prepared by the action of water on sodium hydride.

$$NaH + H_2O \longrightarrow NaOH + H_2$$
(very pure Hydrogen)

6.Sol: On the industrial scale hydrogen is prepared from water gas according to following reaction sequence

$$\underbrace{CO + H_2}_{water\ gas} + \underbrace{H_2O}_{(steam)} \xrightarrow{catalyst} CO_2 + 2H_2$$

$$\xrightarrow[(alkali)]{2NaOH} Na_2CO_3 + H_2O$$

From the above it is clear that CO is first oxidised to CO_2 which is then absorbed in NaOH.

s-BLOCK ELEMENTS [ONLINE QUESTIONS]

1.Sol:

Compound	Nature
CsO_2	Superoxide
SiO_2	Oxide
KO_2	Superoxide
BaO_2	Peroxide

2.Sol: The solubility of sulphates of alkaline earth metals decreases as we move down the group from Be to Ba due to the reason that ionic size increases down the group. The lattice energy remains constant because sulphate ion is so large, so that small change in cationic sizes do not make any difference. Thus, the order will be Mg > Ca . Sr > Ba

3.Sol: Quick lime is commercial name of CaO.

4.Sol: Covalent character increases, when the cation has small size and high charge density. Among all these, $Mg^{2(+)}$ size is smaller so $MgCl_2$ tends to be more covalent in nature.

5.Sol: Na_2O_2 is peroxide. The formula of sodium superoxide is NaO_2.

6.Sol: Higher the lattice enthalpy lower will be solubility i.e., lattce enthalpy $\propto \frac{1}{Solubility}$

Since the lattice enthalpy of alkali metals follow the order Li > Na > K > Rb

Hence the correct order of solubility is

LiF < NaF < KF < RbF

[OFFLINE QUESTIONS]

1.Sol: On heating with excess of air Li, Na and K forms following oxides

$$4Li + O_2 \longrightarrow \underset{Lithium\ monoxide}{2Li_2O}$$

$$2Na + O_2 \xrightarrow{575K} \underset{Sodium\ peroxide}{Na_2O_2}$$

$$K + O_2 \longrightarrow \underset{Potassium\ superoxide}{KO_2}$$

2.Sol: In alkaline earth metals, ionic size increases down the group. The lattice energy remains constant because sulphate ion is so large, so that small change in cationic size does not make any difference. On moving down the group, the degree of hydration of metal ions decreases very much leading to decrease in solubility.

$\therefore\ BeSO_4 > MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$

3.Sol: For $Na \longrightarrow Na^+ + e^-$ $\quad IE_1 = 5.1\ eV$

$\therefore$ For $Na^+ + e^- \longrightarrow$ $\quad EF = -5.1\ eV$

(because the reaction is reverse)

4.Sol: Calcium carbonate on thermal decomposition gives CaO (basic oxide) and CO_2 (Acidic oxide)

$$CaCO_3 \xrightarrow{\Delta} \underset{Basic\ oxide}{CaO} + \underset{Acidic\ oxide}{CO_2} \uparrow$$

5.Sol:

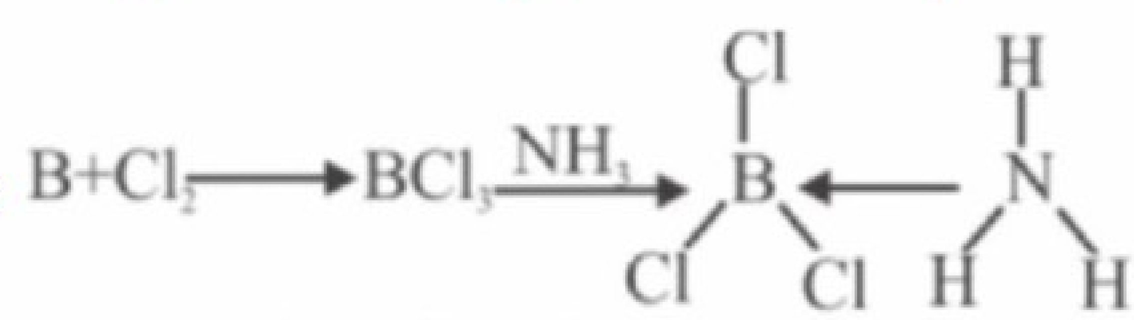
$$O^{2-}(base) + H_2O(acid) \rightarrow OH^-(C.B.) + OH^-(C.A.)$$

O^{2-} acts as Lewis base.

6.Sol: $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

p-BLOCK ELEMENTS [ONLINE QUESTIONS]

1.Sol:



[not dimerise due to $(p\pi - p\pi)$ back bonding]

2.Sol: Lithium hydride react with diborane to produce lithium borohydride.

$$2LiH + B_2H_6 \rightarrow 2Li[BH_4]$$

3.Sol: A - Silica gel packets are used to absorb moisture and keep things dry i.e., as drying agent.

B - Silicon is a semiconductor and is used in transistors.

C - Silicone is used as sealant.

D - Silicates are widely used in ion-exchange beds in domestic and commercial water purification, softening, and other applications.

4.Sol: In diamond, each C-atom is covalently bonded to four other C-atoms to give a tetrahedral unit. In diamond each C-atom is sp^3-hybridized. Therefore each C-atom forms four sigma bonds with neighbouring C-atoms. In diamond each C-atom utilizes its four unpaired electrons in bond formation.These bonding electrons are localized. Due to this reason diamond is a bad conductor of electricity. In graphite each C-atom is covalently bonded to three C-atoms to give trigonal geometry. Each C-atom in graphite is sp^2-hybridized. Three out of four valence electrons of each C-atom are used in bond formation while the fourth electron is free to move in the structure of graphite. Due to this reason graphite is a good conductor of electricity.

5.Sol: Aluminium oxide is amphoteric oxide because it shows the properties of the both acidic and basic oxides. It reacts with both acids and bases to form salt and water.

$$Al_2O_3.xH_2O + 2NaOH \longrightarrow NaAlO_2 + H_2O$$

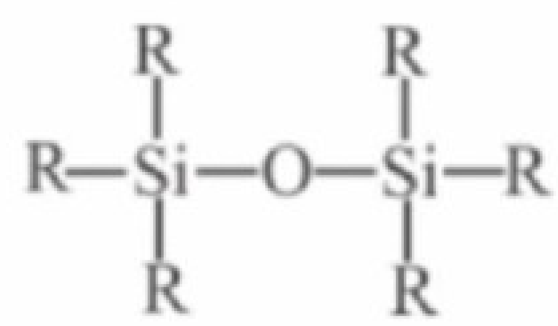
$$Al_2O_3.xH_2O + HCl \longrightarrow AlCl_3 + H_2O$$

6.Sol: $CaF_2 + SiO_2 + H_2SO_4 \longrightarrow$

$$SiF_4 + H_2O + CaSO_4 \xrightarrow{\text{hydrolysis}} CaSiF_6$$

7.Sol: The feldspares are most abundant aluminosilicate minerals in the earth surface. The silicon atoms and aluminium atoms occupy the centres of interlinked tetrahedra of SiO_4^{4-} and AlO_4^{5-}. These tetrahedra connect at each corner to other tetrahedra forming an intricate, three dimensional, negatively charged framework. The sodium cations sit within the voids in this structure.

8.Sol: The hydrolysis of Trialkyl chlorosilane R_3SiCl yields dimer.



9.Sol: Catenation is inversely proportional to bond energy.

CLASS XI

CHEMISTRY KVPY-6

PREVIOUS YEAR QUESTIONS

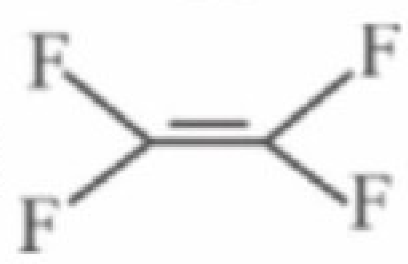
POLYMERS

1. The monomer of Teflon is **[2007]**

(a) 

(b) 

(c) 

(d) 

BIOMOLECULES

1. In the reaction

$\text{Glucose} \xrightarrow{\text{yeast}} X \xrightarrow{KMnO_4} Y$ the products X and Y, respectively, are **[2007]**

(a) EtOH, CH_3COOH
(b) MeOH, HCOOH
(c) EtOH, CH_3CHO
(d) EtOH, $HOCH_2CH_2OH$

CHEMISTRY IN EVERYDAY LIFE

1. Penicillin was discovered by **[2008]**

(a) Alexander G. Fleming
(b) Emil Fischer
(c) Robert B. Woodward
(d) Van't Hoff

ALCOHOLS, PHENOLS & ETHERS

1. Dehydration of 2-pentanol gives **[2008]**

(a) Pentane
(b) Only 1-Pentene
(c) Only 2-pentene
(d) A mixture of 1-Pentene and 2-Pentene

ALDEHYDES, KETONES & CARBOXYLIC ACIDS

1. Esterification of a compound "X" with molecular formula $C_3H_6O_2$ with an alcohol "Y" produces a compound with molecular formula $C_5H_{10}O_2$. X and Y, respectively, are **[2008]**

(a) propanoic acid and methanol
(b) propanoic acid and ethanol
(c) acetic acid and ethanol
(d) butyric acid and methanol

2. Saponification is **[2009]**

(a) hydrolysis of an ester
(b) hydrolysis of an amide
(c) hydrolysis of an ether
(d) hydrolysis of an acid chloride

3. Ethanol on reaction with alkaline $KMnO_4$ gives X which when reacted with methanol in the presence of an acid gives a sweet smelling compound, Y. X and Y respectively, are **[2009]**

(a) acetaldehyde and acetone
(b) acetic acid and methyl acetate
(c) formic acid and methyl formate
(d) ethylene and ethyl methyl ether

HYDROCARBONS

1. When calcium carbide is added to water, the gas that is evolved is **[2009]**

(a) carbon dioxide (b) hydrogen
(c) acetylene (d) methane

ANSWER KEY

POLYMERS

1. d

BIOMOLECULES

1. a

CHEMISTRY IN EVERYDAY LIFE

1. a

ALCOHOLS, PHENOLS & ETHERS

1. d

ALDEHYDES, KETONES & CARBOXYLIC ACIDS

1. b **2.** a **3.** b

HYDROCARBONS

1. c

HINTS & SOLUTIONS

POLYMERS

1.Sol: Monomer of Teflon is Tetrafluoroethene $(CF_2 = CF_2)$

BIOMOLECULES

1.Sol: $C_6H_{12}O_6 \xrightarrow[-2CO_2]{Yeast} 2C_2H_5OH \xrightarrow{KMnO_4} CH_3COOH$

CHEMISTRY IN EVERYDAY LIFE

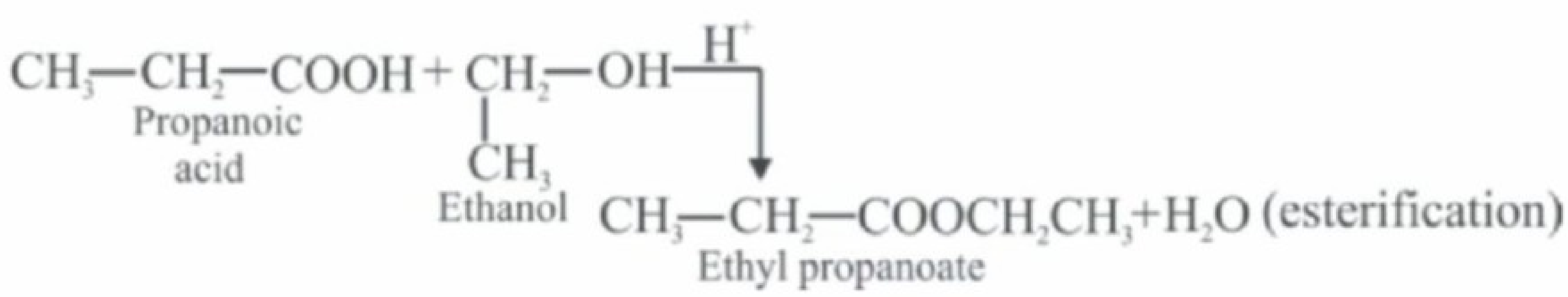
1.Sol: Conceptual

ALCOHOLS, PHENOLS & ETHERS

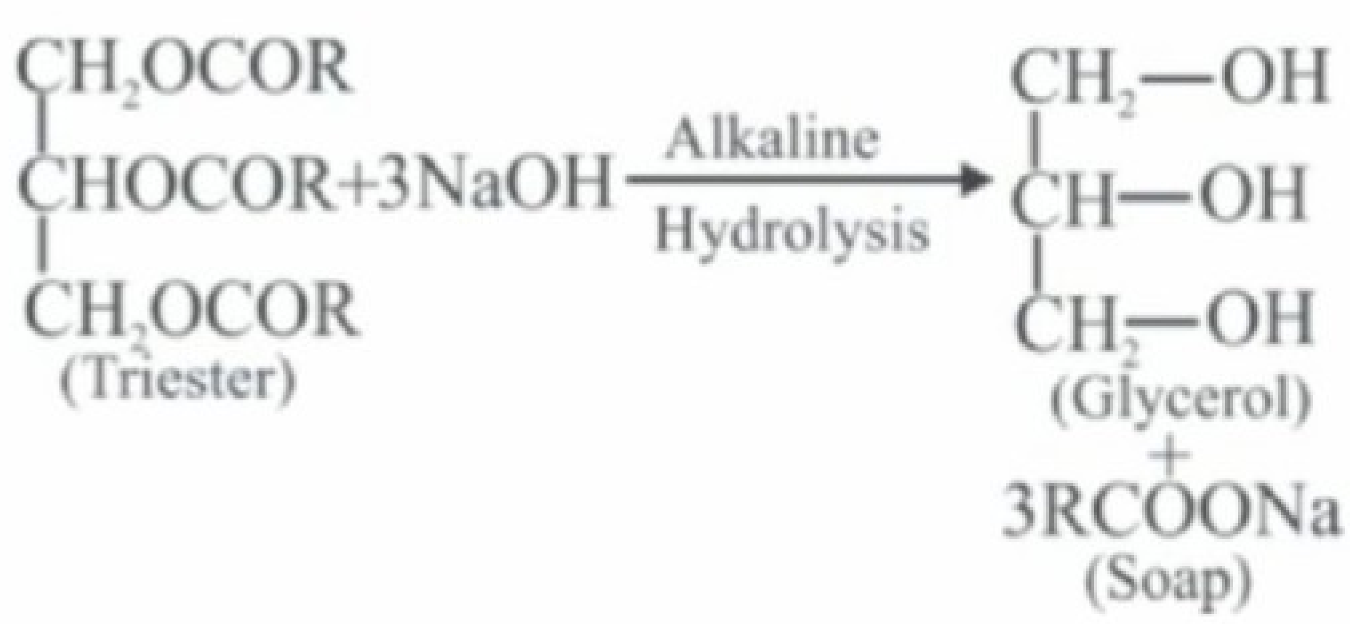
1.Sol: CH_3-CH_2CH_2CH=CH_2 and CH_3CH=$CHCH_2$-CH_3 are formed.

ALDEHYDES, KETONES & CARBOXYLIC ACIDS

1.Sol:



2.Sol:



3.Sol: $\underset{\text{Ethanol}}{CH_3 - CH_2 - OH} \xrightarrow[KMnO_4]{Alkaline} \underset{\text{Acetic acid}}{CH_3COOH}$, $(X)\underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Methanol}}{CH_3OH} \xrightarrow{H^+} \underset{\text{Methyl acetate}(Y)}{CH_3COOCH_3} + H_2O$

HYDROCARBONS

1.Sol: $\underset{\text{Calcium carbide}}{CaC_2} + \underset{\text{water}}{2H_2O} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Ethyne (acetylene)}}{C_2H_2}$

NTSE

MATTER

[2016-2017]

1. Which of the following statement is not correct ? *(Uttarakhand)*
   (a) Latent heat of vaporisation of water is 30.4×10^5 J/kg.
   (b) Temperature of melting of ice does not rise even though heat is continuously supplied.
   (c) The latent heat of fusion of ice is 3.34×10^5 J/kg
   (d) All of the above.

2. Which of the following gas is known as tear gas? *(Uttar Pradesh)*
   (a) Nitrous oxide
   (b) Sulphur dioxide
   (c) Methyl isocyanate
   (d) Chloropicrin

3. The method to purify the colloidal solution is *(Uttar Pradesh)*
   (a) Dialysis (b) Coagulation
   (c) Peptization (d) Bredig's arc method.

4. The dispersion of any liquid in a liquid is known as
   (a) Emulsion. (b) Gum
   (c) Gelatin (d) Gel

5. In the ideal equation $PV = \frac{W}{M}RT$. The quantity 'M' stands for *(West Bengal)*
   (a) molecular weight of the gas
   (b) number of moles of the gas
   (c) gram molecular mass of the gas
   (d) mass of the gas in grams.

[2015-2016]

6. Which of the following expressions is correct for root mean square speed? *(Bihar)*
   (a) $\sqrt{\frac{3RT}{M}}$ (b) $\sqrt{\frac{3P}{d}}$
   (c) $\sqrt{\frac{3PV}{M}}$ (d) All of these

7. Which of the following is heavy water? *(Bihar)*
   (a) H_3O^+ (b) $(H_2O)_n$
   (c) $H(H_2O)_4^+$ (d) D_2O

8. Van der Waals' equation having term "*a*" has the unit *(Bihar)*
   (a) atm L^{-2} mol^{-2} (b) atm L^{-2} mol^{2}
   (c) JK^{-1} mol^{-1} (d) atm L^{2} mol^{-2}

9. Which of the following is correct? *(Bihar)*
   (a) $V \propto P$ (b) $PVR = T$
   (c) $PV = NkT$ (d) $R = k/N_A$

10. When two liquids in a mixture differ by their boiling points, which of the following is the best method to separate these liquids ? *(Chandigarh)*
    (a) Evaporation (b) Chromatography
    (c) Distillation (d) Filtration

11. Which of the following is a compound? *(Gujarat)*
    (a) Washing soda (b) Iron
    (c) Air (d) Mercury

12. Match the Column I with Column II. *(Haryana)*

Column I	Column II
1. Aerosol	(i) Shaving cream
2. Foam	(ii) Face cream
3. Gel	(iii) Clouds
4. Emulsion	(iv) Jelly

	1	2	3	4
(a)	(iii)	(i)	(iv)	(ii)
(b)	(ii)	(i)	(iv)	(iii)
(c)	(iii)	(i)	(ii)	(iv)
(d)	(iv)	(i)	(iii)	(ii)

13. 10 mL of a solution of NaOH is found to be completely neutralised by 8 mL of a given solution of HCl. If we take 20 mL of a given solution of NaOH, the amount of HCl solution (the same solution as before) required to neutralise it will be *(Jharkhand)*

(a) 16 mL (b) 8 mL
(c) 12mL (d) 4 mL

14. Match the column I with Column II.

Column I	Column II
(1) Football inflated inside and then taken outside on a winter day shrinks slightly	(i) Diffusion
(2) Deep sea fish die of when brought diffusion	(ii) Graham's law
(3) A ballon filled with helium will deflate a little bit everyday	(iii) Charles's law
(4) $r \propto \frac{1}{\sqrt{d}}$	(iv) Boyle's law

(Karnataka)

(a) 1-ii , 2-iii, 3-i, 4-iv
(b) 1-iii, 2-iv, 3-i, 4-ii
(c) 1-iv, 2-iii, 3-i, 4-i
(d) 1-iii, 2-iv, 3-ii, 4-i

15. The ratio of hydrogen and oxygen by mass in water is *(Maharashtra)*

(a) 1:2 (b) 8:1 (c) 2:1 (d) 1:8

16. In the equation, $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ the volume of CO_2 gas formed when 2.5 g $CaCO_3$ are completely dissolved in excess of hydrochloric acid at $0°C$ and 1 atm pressure is *(Odisha)*

(a) 0.28 L (b) 0.56 L
(c) 1.12 L (d) 5.6 L.

17. Which of the following will show Tyndall effect? *(Punjab)*

(a) Salt $+H_2O$ (b) $CuSO_4+H_2O$
(c) Milk $+H_2O$ (d) Alcohol $+H_2O$

18. Match the following correctly. *(Punjab)*

Column I	Column II
(I) Washing soda	(w) Hygroscopic substance
(II) Sulphuric acid	(x) Have water of crystallization
(III) Suspension	(y) Coagulation takes place on addition of salt
(IV) Colloid	(z) Particle settle down on standing

(a) I (w) II(x) III (y) IV(z)
(b) I (x) II(z) III (w) IV(y)
(c) I (z) II(y) III (x) IV(w)
(d) I (x) II(w) III (z) IV(y)

19. In open vessel, the liquid keeps on evaporatting.The particles of liquid absorb energy from surrounding to regain the energy lost during evaporation. This absorption of energy from the surrounding makes the surroundings...........

(i) Hot (ii) Cold
(iii) No change in temperature of surrounding
(iv) It depends upon the nature of liquid.

Out of (i), (ii), (iii), (iv)Which is correct to fill the above statement? *(Punjab)*

(a) Only (ii) is correct
(b) (i) and (ii) are correct
(c) Only (i) is correct
(d) All are correct.

20. Milk of magnesia is an example of which type of colloid? *(Rajasthan)*

(a) Gel (b) Sol
(c) Emulsion (d) Form

21. Which of the following is a suitable method to separate two miscible liquids whose difference in boiling point is 36 K? *(Tamil Nadu)*

(a) Evaporation (b) Sublimation
(c) Fractional (d) Distillation

22. Gases can be liquefied *(Tamill Nadu)*

(a) By increasing temperature and pressure
(b) By increasing temperature and decreasing pressure

(c) By decreasing pressure and temperature
(d) By decreasing temperature and increasing pressure

23. The substance which is known as "dry ice" is *(Telangana)*
(a) Solid carbon dioxide.
(b) Copper sulphate
(c) Sulphur dioxide
(d) Potassium permanganate

24. The colloidal solution among the following is *(Telangana)*
(a) Sulphur dioxide
(b) Oil in water
(c) Milk
(d) Chalk powder in water

25. 0.25 mole of a hydrocarbon requires 0.5 mole of hydrogen for complete saturation. Possible formula of the hydrocarbon is *(West Bengal)*
(a) C_3H_8 (b) C_3H_6 (c) C_3H_4 (d) C_4H_8

26. A mixture of CH_4, C_2H_4, and C_2H_2 is passed through a basic copper (I) chloride solution. Which gas/gases will come out? *(West Bengal)*
(a) CH_4 and C_2H_4 (b) CH_4 and C_2H_2
(c) Whole mixture (d) C_2H_4

[2014-2015]

27. If Z is a compressibility factor,van der Waals's equation at low pressure can be written as *(Bihar)*

(a) $Z=1+\frac{Pb}{RT}$ (b) $Z=1-\frac{Pb}{RT}$

(c) $Z=1-\frac{a}{VRT}$ (d) $Z=1+\frac{RT}{Pb}$

28. A mixture of sulphur and carbon disulphide is *(Chandigarh)*
(a) Heterogeneous and shows Tyndall effect
(b) Homogeneous and does not show Tyndall effect
(c) Homogeneous and shows Tyndall effect
(d) Heterogeneous and does not show Tyndall effect

29. Which of the following shows the Tyndall effect? *(Chhattisgarh)*
(i) Commom salt
(ii) Milk
(iii) Copper sulphate solution
(iv) Starch solution
(a) (i) and (ii) (b) (iii) and (iv)
(c) ((ii) and (iv) (d) (ii) and (iii)

30. The percentage of gold present in 20 carat gold is *(Jharkhand)*
(a) 73.86% (b) 83.33%
(c) 50% (d) 100 %

31. 8.7 g of pure MnO_2 is heated with an excess of HCl and the gas evolved is passed into a solution of KI. Calculate the weight of the iodine liberated (Mn=55, Cl=35.5, I=127). *(Jharkhand)*
(a) 25.4 g (b) 7.77 g
(c) 12.70 g (d) 16.41 g

32. The action of syringe is an example of *(Karnataka)*
(a) Charles's law (b) Graham's law
(c) Boyle's (d) Diffusion

33. Pick up odd one out *(Odisha)*
(a) Brass
(b) A crystal of green vitriol
(c) Air
(d) Gun powder

34. An example of the condensation method for the prepration of a colloid is *(Odisha)*
(a) Electrical dispersion
(b) Peptization.
(c) Hydrolysis
(d) Mechanical disintegration

35. Which of the following is not a suspension? *(Odisha)*
(a) Muddy water (b) Dust storm
(c) Milk (d) Aluminium paint

36. The boiling point of a gas is $-80°C$ .The temperature is equivalent to *(Rajasthan)*
(a) 193 K (b) -193 K
(c) 353 K (d) -353 K

37. Which of the following solutions does not shown Tyndall effect? *(Rajasthan)*
(a) Milk (b) Starch solution
(c) $CuSO_4$ solution (d) Gold sol

38. Dry ice is an example of ------ Process. *(Tamil Nadu)*

(a) Evaporation (b) Sublimation
(c) Purification (d) Crystallization

39. Solubility of KNO_3 *(Tamil Nadu)*
(a) Is not related to the temperature Fluctuations
(b) Remains constant with temperature
(c) Decreases with temperature
(d) Increases with temperature

40. Under the same conditions of temperature and pressure,one litre of Oxygen gas was mixed with one litre of carbon dioxide gas. The mass ratio of the gases in the mixture will be *(West Bengal)*
(a) 16:44 (b) 1 : 1 (c) 11:8 (d) 8 :11

41. Which of the following is not the unit of the universal gas constant *(West Bengal)*
(a) Pa m^2 mol^{-1} K^{-1} (b) J mol^{-1} K^{-1}
(c) erg mol^{-1} K^{-1} (d) Pa m^3 mol^{-1} K^{-1}

42. n_1 molecules of gas is removed from the container of definite volume at a temperature of $T°C$ and at a pressure P. What will be the pressure of the gas at that temperature when n_2 molecules of gas is removed from the container? *(West Bengal)*

(a) $\frac{(n_1+n_2)}{n_2P}$ (b) $\frac{n_1P}{(n_2-n_2)}$

(c) $\frac{(n_1-n_2)p}{n_1}$ (d) $\frac{(n_1-n_2)p}{n_2}$

ANSWER KEY

1. a	2. d	3 . a	4. a	5. a
6. d	7. d	8. d	9. c	10. c
11. a	12. a	13. a	14. b	15. d
16. b	17. c	18. d	19. a	20. b
21. d	22. d	23. a	24. c	25. c
26. a	27. c	28. b	29. c	30. a
31. a	32. c	33. b	34. c	35. c
36. a	37. c	38. b	39. d	40. d
41. a	42. c			

HINTS & SOLUTIONS

1.Sol: The latent heat of vaporisation of water is 22.59×10^5 J/kg

2.Sol: Conceptual

3.Sol: The process of separating the particles of colloids from impurities of the mixture by diffusion through a parchment or an animal membrane is known as dialysis.

4.Sol: In emulsion , both the dispersed phase and dispersion medium are liquids

5.Sol: $PV = nRT = \frac{W}{M}RT$ Where,

W = Weight of a gas
M = Molecular weight of gas

6.Sol: $u_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3P}{d}}$

7.Sol: Conceptual

8.Sol: Van der Waals' constant

$$a = \frac{P\times V^2}{n^2} = \text{atm } L^2 \text{ mol}^{-2}$$

9.Sol: According to ideal gas equation,

$PV = nRT$ $(n = \text{number of moles})$

or

$$\frac{PV}{N_A} = \frac{n}{N_A}RT$$

$(N_A = \text{Avogadro's constant})$

or $\frac{PV}{N_A} = nKT$

$\left(k = \text{Boltzmann constant} = \frac{R}{N_A}\right)$

or, $PV = nN_AkT$

or, $PV = NkT$ $(N = \text{Number of molecules})$

10.Sol: Conceptual

11.Sol: Iron, mercury are elements, air is a mixture.

12.Sol: Conceptual

13.Sol: 10 mL NaOH is neutralised by 8 mL of HCl 20mL NaOH is neutralised by

$$\frac{8\times 20}{10}=16 \text{ mL of HCl}$$

14.Sol: Conceptual

15.Sol: In $H_2O; H:O=2:16=1:8$

16.Sol: $CaCO_3+2HCl\rightarrow CaCl_2+H_2O+CO_2$

100g 22.4 L

100g $CaCO_3$ produces 22.4L CO_2 at N.T.P

$$\therefore 2.5gCaCO_3 \text{Produces} = \frac{22.4\times 2.5}{100}=0.56L\ CO_2$$

at N.T.P.

17.Sol: It is a colloidal solution

18.Sol: Conceptual

19.Sol: Conceptual

20.Sol: In milk of magnesia, the dispersed phase is solid and dispersion medium is liquid.

21.Sol: Distillation is used for the separation of two miscible liquids which boil without decomposition and sufficient difference $(30K-50K)$ in their boiling points.

22.Sol: Conceptual

23.Sol: Solid carbon dioxide is known as dry ice.

24.Sol: Conceptual

25.Sol: 0.25 mole of the hydrocarbon requires 0.5 mole of hydrogen. or, one mole of hydrocarbon requires 2 moles of hydrogen.For complete saturation, the hydrocarbon requires 2 moles of hydrogen, hence it is analkyne.

$$C_3H_4 + 2H_2 \rightarrow C_3H_8$$

1mole 2mole 1mole

0.25 mole 0.5 mole 0.25 mole

26.Sol: C_2H_2 is absorbed in basic copper (I) chloride solution. So, CH_4 and C_2H_4 will come out.

27.Sol: For one mole of gas van der Waals's equation can be written as

$$\therefore\left(p+\frac{a}{V^2}\right)(V-b)=RT$$

At low pressure, v>>b, hence b can be neglected.

$$\therefore\left(p+\frac{a}{V^2}\right)V=RT$$

or, $pv+\frac{a}{V}=RT$ or $PV=RT-\frac{a}{V}$

or, $\frac{PV}{RT}=1-\frac{a}{RTV}$ or $Z=1-\frac{a}{RTV}$

28.Sol: Sulphur is soluble in carbon disulphide hence,a solution is formed when sulphur is mixed with carbon disulphide. Solution is homogeneous and does not show Tyndall effect.

29.Sol: Milk and starch solution are colloidal solutions.

30.Sol: 24 carat gold= 197 g gold

$$\therefore 20\text{carat gold}=\frac{20\times 197}{24}=164.16g$$

Percent of gold present in 24 carat gold (197 g gold) =100%

$\therefore$ Percent of gold present in 20 carat gold

$$=\frac{164.16\times 100}{197}=83.33\%$$

31.Sol:

$$MnO_2+4HCl\rightarrow MnCl_2+Cl_2+2H_2O$$

87g 71g

87 g MnO_2 produces 71 g Cl_2

$\therefore$ 8.7 g MnO_2 produces 7.1 g Cl_2

$$\underset{71\,g}{Cl_2}+2KI\rightarrow 2KCl+\underset{254g}{I_2}$$

71 g Cl_2 on passing into a solution of KI produces 254 g I_2.

7.1 g Cl_2 on passing into a solution of KI produces 25.4 g I_2.

32.Sol: In a syringe, the volume of a fixed amount of gas is increased by drawing the handle back, thereby decreasing the pressure. The blood in a vein has higher pressure than the gas in the syringe, so it flows into the syringe, equalizing the pressure differential.

33.Sol: Green vitriol is a compound whereas air, brass and gun powder are mixtures.

34.Sol: Condensation methods involve the going

together of a large number of smaller particles to from particles of colloidal size. $Fe(OH)_3$ and $Al(OH)_3$ sols are obtained by boiling solutions of their corresponding chlorides, e.g.,

$$\underset{\text{Colloidal sol}}{FeCl_3 + 3H_2O \rightarrow Fe(OH)_3 + 3HCl}$$

35.Sol: Milk is a colloid.

36.Sol: $-80°C = (-80+273)K = 193K$

37.Sol: Sugar solution is not a colloidal solution.

38.Sol: $CO_{2(s)} \rightarrow CO_{2(g)}$

Dry ice sublimes at 195 K.

39.Sol: $KNO_{3(S)} + \text{Water} + \text{Heat} \rightarrow KNO_{3(aq)}$

Dissolution of KNO_3in an endothermic reaction. Solubility of KNO_3 increases with temperature

40.Sol: Under STP, 22.4 litre oxygen weighs 32 g.

$\therefore$ 1 litre oxygen weighs $= \dfrac{32}{22.4} g$

22.4 litre carbon dioxide weighs 44 g

$\therefore$ 1 litre carbon dioxide weighs $= \dfrac{44}{22.4} g$

$\therefore$ Mass ratio $= \dfrac{32}{22.4} : \dfrac{44}{22.4} = 32:44 = 8:11$

41.Sol: Conceptual

42.Sol: $P = \dfrac{n_1 RT}{V}, P' = \dfrac{n_1 RT}{V}$

Noe, final pressure,

$$P_f = P - P' = \frac{n_1 RT}{V} - \frac{n_1 RT}{V} = \frac{RT}{V}(n_1 - n_2)$$

$$= \frac{p}{n^1}(n_1 - n_2)$$

$$= \left(\frac{n_1 - n_2}{n_1}\right)p \qquad \left[\begin{array}{l} \therefore P = \dfrac{n_1 RT}{V} \\ \therefore \dfrac{RT}{V} = \dfrac{P}{n_1} \end{array}\right]$$

Previous years NEET/AIPMT Questions

REDOX REACTIONS

1. The correct order of N-compounds in its decreasing order of oxidation states is **[2018]**

(a) HNO_3, NH_4Cl, NO, N_2

(b) NH_4Cl, N_2, NO, HNO_3

(c) HNO_3, NO, NH_4Cl, N_2

(d) HNO_3, NO, N_2, NH_4Cl

2. For the redox reaction

$MnO_4^- + C_2O_4^{2-} + H^+ \rightarrow Mn^{2+} + CO_2 + H_2O$

The correct coefficient of the reactants for the balanced equation are **[2018]**

	MnO_4^-	$C_2O_4^{2-}$	H^+
(a)	2	16	5
(b)	5	16	2
(c)	2	5	16
(d)	16	5	2

3. The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic condition gives **[2014]**

(a) Mn^{4+} and O_2 (b) Mn^{2+} and O_2

(c) Mn^{2+} and O_3 (d) Mn^{4+} and MnO_2

4. In acidic medium, H_2O_2 changes $Cr_2O_7^{2-}$ to CrO_5 which has two $(-O-O-)$ bonds. Oxidation state of Cr in CrO_5 is **[2014]**

(a) + 5 (b) + 3 (c) + 6 (d) - 10

5. (I) $H_2O_2 + O_3 \longrightarrow H_2O + 2O_2$

(II) $H_2O_2 + Ag_2O \longrightarrow 2Ag + H_2O + O_2$

Role of hydrogen peroxide in the above reactions is respectively **[2014]**

(a) Oxidizing in (I) and reducing in (II)

(b) Reducing in (I) and oxidizing in (II)

(c) Reducing in (I) and (II)

(d) Oxidizing in (I) and (II)

6. The pair of compounds that can exist together is **[2014]**

(a) $FeCl_3, SnCl_2$ (b) $HgCl_2, SnCl_2$

(c) $FeCl_2, SnCl_2$ (d) $FeCl_3, KI$

7. A mixture of potassium chlorate, oxalic acid and sulphuric acid is heated. During the reaction which element undergoes maximum change in the oxidation number? **[2012]**

(a) Cl (b) C (c) S (d) H

8. When Cl_2 gas reacts with hot and concentrated sodium hydroxide solution, the oxidation number of chlorine changes from **[2012]**

(a) Zero to -1 and Zero to +3

(b) Zero to +1 and zero to -3

(c) Zero to +1 and zero to -5

(d) Zero to -1 and zero to +5

9. In which of the following compounds, nitrogen exhibits the highest oxidation state? **[2012]**

(a) N_3H (b) NH_2OH

(c) N_2H_4 (d) NH_3

10. Standard reduction potensials of the half reactions are given below **[2012]**

(a) $F_2(g)+2e^- \longrightarrow 2F^-(aq); E^\circ = +2.85V$

(b) $Cl_2(g)+2e^- \longrightarrow 2Cl^-(aq); E^\circ = +1.36V$

(c) $Br_2(l)+2e^- \longrightarrow 2Br^-(aq); E^\circ = +1.06V$

(d) $I_2(s)+2e^- \longrightarrow 2I^-(aq); E^\circ = +0.53V$

11. Which of the following oxidation state is the most common among the lanthanides? **[2010]**

(a) 4 (b) 2 (c) 5 (d) 3

12. Oxidation no. of P in $H_4P_2O_5, H_4P_2O_6$, and $H_4P_2O_7$ are respectively **[2010]**

(a) +3, +4, +5 (b) +4, +3, +5
(c) +3, +5, +4 (d) +5, +3, +4

13. Oxidation numbers of P in PO_4^{3-} of S in SO_4^{2-} and that of Cr in $Cr_2O_7^{2-}$ are respectively: **[2009]**

(a) -3, +6 and +6 (b) +5, +3 and +6
(c) +3, +6 and +5 (d) +5, +6 and +6

s-BLOCK ELEMENTS

1. Among CaH_2, BeH_2, BaH_2, the order of ionic character is **[2018]**

(a) $BeH_2 < BaH_2 < CaH_2$

(b) $BaH_2 < BeH_2 < CaH_2$

(c) $CaH_2 < BeH_2 < BaH_2$

(d) $BeH_2 < CaH_2 < BaH_2$

2. Which of the following statements is false? **[2016]**

(a) Mg^{2+} ions are important in the green parts of plants

(b) Mg^{2+} ions form a complex with ATP

(c) Ca^{2+} ions are important in blood clotting

(d) Ca^{2+} ions are not important in maintaining the regular beating of the heart

3. Solubility of the alkaline earth's metal sulphates in water decrease in the sequence **[2015]**

(a) $Ca > Sr > Ba > Mg$

(b) $Sr > Ca > Mg > Ba$

(c) $Ba > Mg > Sr > Ca$

(d) $Mg > Ca > Sr > Ba$

4. Which of the following compounds has the lowest melting point? **[2011]**

(a) CaF_2 (b) $CaCl_2$ (c) $CaBr_2$ (d) CaI_2

5. Which of the following alkaline earth metal sulphates has hydration enthalpy higher than its lattice enthalpy? **[2010]**

(a) $CaSO_4$ (b) $BeSO_4$ (c) $BaSO_4$ (d) $SrSO_4$

6. Property of the alkaline earth metals that increases with their atomic number **[2010]**

(a) Solubility of their hydroxides in water
(b) Solubility of their sulphates in water
(c) Ionisation energy
(d) Electronegativity

7. Which of the following compounds is a peroxide? **[2010]**

(a) KO_2 (b) BaO_2 (c) MnO_2 (d) NO_2

p-BLOCK ELEMENTS

1. Which one of the following elements is unable to form MF_6^{3-} ion? **[2018]**

(a) B (b) In (c) Al (d) Ga

2. The correct order of atomic radii in group 13 elements is **[2018]**

(a) $B < Ga < Al < Tl < In$

(b) $B < Ga < Al < In < Tl$

(c) $B < Al < Ga < In < Tl$

(d) $B < Al < In < Ga < Tl$

3. The stability of +1 oxidation state among Al, Ga, In and Ti increases in the sequence **[2015]**

(a) Tl < In < Ga < Al (b) In < Tl < Ga < Al
(c) Ga < In < Al < Tl (d) Al < Ga < In < Tl

4. Which of the following structure is similar to graphite? **[2013]**

(a) B (b) B_4C (c) B_2H_6 (d) BN

5. Which of these is not a monomer for a high molecular mass silicone polymer? **[2013]**

(a) Me_2SiCl_2 (b) Me_3SiCl

(c) $PhSiCl_3$ (d) $MeSiCl_3$

6. The basic structural unit of silicates is **[2013]**

(a) SiO_4^{4-} (b) SiO_3^{2-} (c) SiO_4^{2-} (d) SiO^-

7. Aluminium is extracted from alumina (Al_2O_3) by electrolysis of molten mixture of **[2012]**

(a) $Al_2O_3 + Na_3AlF_6 + CaF_2$

(b) $Al_2O_3 + KF + Na_3AlF_6$

(c) $Al_2O_3 + HF + NaAlF_4$

(d) $Al_2O_3 + CaF_2 + NaAlF_4$

8. Name the type of the structure of silicate in which one oxygen atom of $[SiO_4]^{4-}$ is shared **[2011]**

(a) Three dimensional
(b) Linear chain silicate
(c) Sheet silicate (d) Pyrosilicate

9. The stability of +1 oxidation state increases in the sequence **[2009]**

(a) Ga < In < Al < Tl (b) AI < Ga < In < Tl
(c) Tl < In < Ga < Al (d) In < Ti < Ga < Al

10. Which of the following anion is present in chain structure of silicate? **[2007]**

(a) $[Si_2O_5^{2-}]_n$ (b) $[SiO_3^{2-}]_n$

(c) SiO_4^{4-} (d) $Si_2O_7^{6-}$

11. Which oxidation states are the most characteristics of lead and tin respectively? **[2007]**

(a) +2, +4 (b) +4, +4
(c) +2, +2 (d) +4, +2

ANSWER KEY

REDOX REACTIONS

1. d	2. c	3. b	4. c	5. a
6. c	7. a	8. d	9. a	10. a
11. d	12. a	13. d		

s-BLOCK ELEMENTS

1. d	2. d	3. d	4. d	5. b
6. a	7. b			

p-BLOCK ELEMENTS

1. a	2. b	3. d	4. d	5. b
6. a	7. a	8. d	9. b	10. b
11. a				

HINTS & SOLUTIONS

REDOX REACTIONS

1.Sol:

	HNO_3	NO	N_2	NH_4Cl
Oxidation No	+5	+2	0	−3

2.Sol:

$$MnO_4^- + C_2O_4^{2-} + H^+ \longrightarrow Mn^{2+} + 2CO_2 + H_2O$$

+7 +3 +2 +4

gain of $5e^-$

loss of $1\ e^-$

or ac code into ion-electron method

(1) $MnO_4^- \rightarrow Mn^{2+}$
(2) $MnO_4^- \rightarrow Mn^{2+} + 4H_2O$
(3) $MnO_4^- + 8H^+ \rightarrow Mn^{2+} + 4H_2O$
(4) $(MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O) \times 2$ ...(I)

(1) $C_2O_4^{2-} \rightarrow CO_2$
(2) $C_2O_4^{2-} \rightarrow 2CO_2$
(3) $(C_2O_4^{2-} \rightarrow 2CO_2 + 2e^-) \times 5$ ...(II)

$$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{2+} + 8H_2O$$
$$5C_2O_4^{2-} \rightarrow 10CO_2 + 10e^-$$
$$\overline{2MnO_4^- + 5C_2O_4^{2-} + 16H^+ \rightarrow 2Mn^+ + 10CO_2 + 8H_2O}$$

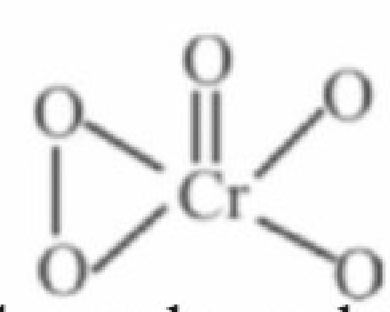
3.Sol: The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic medium is

$$3H_2SO_4 + 2KMnO_4 + 5H_2O_2 \longrightarrow 5O_2 + 2MnSO_4 + 8H_2O + K_2SO_4$$

In the above reaction, $KMnO_4$ oxidises H_2O_2 to O_2 and MnO_4^- gets reduced to Mn^{2+} ion as $MnSO_4$. Hence, aqueous solution of $KMnO_4$ with H_2O_2 yields Mn^{2+} and O_2 in acidic conditions.

4.Sol: When H_2O is added to an acidified solution of a dichromate, $Cr_2O_7^{2-}$, a deep blue coloured complex,chromic peroxide, CrO_5[or $CrO(O_2)_2$] is formed.

$$CrO_7^{2-} + 2H^+ + 4H_2O_2 \longrightarrow \underset{\text{Chromic peroxide}}{2Cr\,O(O_2)_2} + 5H_2O$$



This deep blue coloured complex has the above mentioned structure. Oxidation state Cr is +6 is due to the presence of two peroxide linkages,

which can be calculated as Cr peroxide normal

$$x+(-1)4+(-2)=0$$
$$x-6=0$$
$$x=+6$$

5.Sol: In the reaction,

oxidation

$$\overset{+1\,-1}{H_2O_2}+\overset{0,-2}{O_3}\longrightarrow\overset{+1\,-2}{H_2O}+\overset{0}{2O_2}$$

reduction

Since H_2O_2 oxidises, O_3 into O_2, thus it behaves as an oxidising agent.
Further, in the reaction,

$$\overset{+1\,-1}{H_2O_2}+\overset{+1,\,-2}{Ag_2O}\longrightarrow\overset{0}{2Ag}+\overset{-1\,-2}{H_2O}+\overset{0}{O_2}$$

reduction

oxidation

Here H_2O_2 reduces Ag_2O into metallic silver [Ag] (as oxidation number is reducing from +1 to 0). Thus, H_2O_2 bahaves as a reducing agent.

6.Sol: The compounds with lower oxidation number and which cannot reduced by one another can exist together. Thus, $FeCl_2$ and $SnCl_2$ can exist together as Fe^{2+} cannot be reduced by Sn^{2+}.

7.Sol:

$$\overset{+1\,+5\,-2}{KClO_3}+\overset{+1\,+3\,-2}{H_2C_2O_4}+\overset{+1\,+6\,-2}{H_2SO_4}\longrightarrow\overset{+1\,+6\,-2}{K_2SO_4}+\overset{+1\,-1}{KCl}+\overset{+4\,-2}{CO_2}+\overset{+1\,-2}{H_2O}$$

$\therefore$ Cl is the element which undergoes maximum change in the oxidation state.

8.Sol: In disproportionation reaction, the same element undergoes oxidation as well as reduction.

oxidation

$$3\overset{0}{Cl}+6NaOH\xrightarrow[\text{Hot and conc.}]{}5Na\overset{-1}{Cl}+Na\overset{+5}{Cl}O_3+3H_2O$$

reduction

In this process, oxidation number of chlorine changes from 0 to -1 and 0 to +5.

9.Sol: Let the oxidation state of nitrogen in the given compounds be x.

(a) $\overset{x\ \ +1}{N_3H}\Rightarrow(x)3+(+1)=0\Rightarrow 3x=-1$

$$\Rightarrow\quad x=-\frac{1}{3}$$

(b) $\overset{x\,+1\,-2\,+1}{NH_2OH}\Rightarrow x+(+1)2+(-2)+(+1)=0$

$$x+2-2+1=0\Rightarrow x=-1$$

(c) $\overset{x\,+1}{N_2H_4}\Rightarrow 2(x)+(+1)4=0$

$$\Rightarrow 2x=-4\Rightarrow x=-2$$

(d) $\overset{x\,+1}{NH_3}\Rightarrow x+(+1)3=0$

$$x=-3$$

$\therefore$ Oxidation state of nitrogen is highest in N_3H.

10.Sol: The higher the value of reduction potential, the higher will be the oxidising pwer whereas the lower the value of reduction potential the higher will be reducing power.

11.Sol: +3 is the most common oxidation state among the lanthanides.

12.Sol: $H_4P_2O_5: 4\times1+2\times a-5\times2=0$

$$a=+3$$
$$H_4P_2O_6: 4\times1+2\times a-6\times2=0$$
$$a=+4$$
$$H_4P_2O_7: 4\times1+2\times a-7\times2=0$$
$$a=+5$$

13.Sol: Oxidation no. in each case.

$$PO_4^{3-}$$
$$x+4(-2)=-3x=+5$$
$$SO_4^{2-}$$
$$x+(-2\times4)=-2$$
$$x-8=-2$$
$$x=-2+8x=+6$$
$$Cr_2O_7^{2-}$$
$$2x+(-2\times7)=-2$$
$$2x-14=-2$$
$$2x=-2+14$$
$$2x=12$$
$$x=+6$$

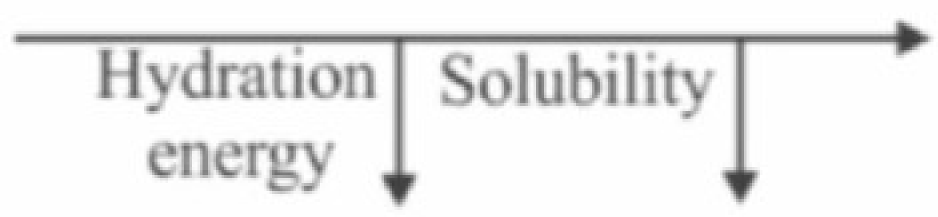
s-BLOCK ELEMENTS

1.Sol: As we move from Be^{2+} to Ba^{2+} ionic radius increase ionic character increases (Fajan's Rules)

2.Sol: Ca^{2+} ions are important clotting and are also important in maintaining the regular beating of the heart.

3.Sol: Solubility of alkaline earth metal sulphates decreases down the group due to decrease in hydration energy.

$$MgSO_4 > CaSO_4 > SrSO_4 > BaSO_4$$



4.Sol: CaI_2 has the maximum covalent character due to large size of anion and possesses lowest energy. Thus, melting point is lowest.

5.Sol: Be^{2+} is very small, hence its hydration enthalpy is greater than its lattice enthalpy

6.Sol: Lattice energy decreases more rapidly than hydration energy for alkaline earth metal hydroxides

7.Sol: $BaO_2 + H_2SO_4 \longrightarrow H_2O_2 + BaSO_4$

p-BLOCK ELEMENTS

1.Sol: Due to non-availability of vacant 'd' orbital.

2.Sol: Atomic radius of Al > Atomic radius Ga

Expected B < Al < Ga < In < Tl

Observed B < Ga < Al < In < Tl

3.Sol: Stability of +1 oxidation state due to inert pair effect.

Tl > In > Ga > Al

4.Sol: BN has hexagonal form like layer structure of graphite. Boron nitride (BN) is also called inorganic graphite.

5.Sol: Me_3SiCl on hydrolysis forms a dimer, not a polymer

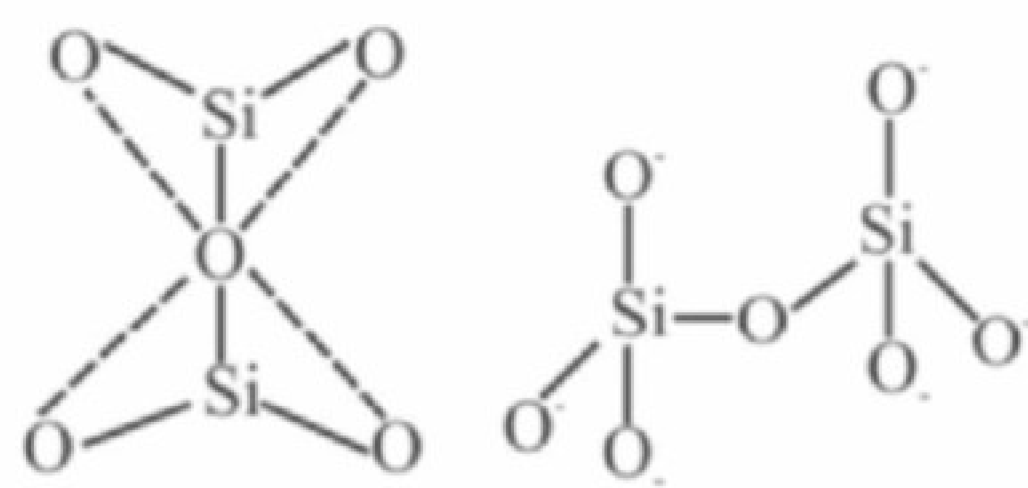
$$Me_3SiCl + HOH \longrightarrow Me_3SiOH + HCl$$

$$Me_3SiOH + HOSiMe_3 \longrightarrow Me_3Si-O-SiMe_3$$

6.Sol: The basic unit of all silicate is SiO_4^{4-}

7.Sol: Extraction of Al from Al_2O_3 is made by electrolytic reduction of molten mixture of alumina (Al_2O_3), cryolite (Na_3AlF_6) and fluorspar CaF_2

8.Sol: In these two SiO_4^{4-} tetrahedral share a common oxygen island structure having formula $(Si_2O_7)^{6-}$. These are also called island silicate.



9.Sol: The given elements belong to third group. There elements mainly exhibit +3 and +1 oxidation states. As we know that, the stability of lower oxidation state, i.e., +1 state, increases on moving down a group, the sequence of stability is Al < Ga < In < Tl

10.Sol: Chain silicates involving sharing of two oxygen atoms by each tetrahedral are of two types:

(i) Having $(SiO_3^{2-})_n$ units

(ii) Having $(Si_4O_{11}^{6-})_n$ units

11.Sol: The tendency to form +2 ionic state increases on moving down the group due to inert pair effect.

Most characteristic oxidation states for lead and tin are +2 and +4 respectively.

NSE - CHEMISTRY

CLASS X

CHEMICAL EQUILIBRIUM

[2006-07]

1. Increased pressure shift the equilibrium of the reaction $N_2(g)+3H_2(g) \rightleftharpoons 2NH_3(g)$ so as to
   (a) Produce more $N_2(g)$ and $H_2(g)$
   (b) Form more ammonia gas.
   (c) Product more $H_2(g)$.
   (d) Keep the conversion to ammonia unaltered.

2 The compound that may be added to water to increase its pH from 7 to higher value is
   (a) $AlCl_3$ (b) Na_2CO_3
   (c) HCl (d) $NaCl$

3. The most basic aqueous solution is
   (a) Na_2CO_3 (b) CH_3COONa
   (c) Na_2HPO_4 (d) $NaCl$

4. Slightly soluble Ag_2CrO_4 is expected to be more soluble in
   (a) 0.01 M K_2CrO_4 (b) 0.1 M HNO_3
   (c) 0.1 M $AgNO_3$ (d) pure water

5. If 25 mL of 0.01 N NaOH is added to 50 mL of 0.01 N acetic acid, the pH of resultant solution will be (pK_a of $CH_3COOH = 4.76$)
   (a) 4.5 (b) 5.5
   (c) 2.48 (d) 4.76

6. Pure water is saturated with sparingly soluble salt PbI_2 which has solubility product K_{sp}. In this saturated solution
   (a) $[Pb^{2+}]=K_{sp}$ (b) $[Pb^{2+}]=[I^-]$
   (c) $2[Pb]^{2+}=[I^-]$ (d) $[Pb^{2+}]=K_{sp}^{1/2}$

7. Thermodynamically most stable allotrope of carbon is
   (a) Graphite (b) Diamond
   (c) C_{70} (d) C_{60}

[2005-06]

8. When $K_c >> 1$ for a chemical reaction,
   (a) The equilibrium would be achieved slowly.
   (b) The equilibrium would be achieved rapidly.
   (c) Reactant concentration would be much greater than product concentration.
   (d) Product concentration would be much greater than reactant concentrations at equilibrium.

9. What is the pH of 10^{-3} N CH_3COOH solution? (Dissociation constant of CH_3COOH is 1.74×10^{-5})
   (a) 4.76 (b) 3.88
   (b) 3.0 (d) 5.55

10. The ionic product of water at 25°C is 10^{-14}. The corresponding dissociation constant is
   (a) 3.6×10^{-16} (b) 3.0×10^{-16}
   (c) 1.8×10^{-16} (d) 1.5×10^{-6}

11. The solubility product of $Mg(OH)_2$ is 3.4×10^{-11} mol^3L^{-3}. What will be its solubility in gL^{-1}? (molecular weight of $Mg(OH)_2$ is 58)
   (a) 1.2×10^{-2} (b) 2.0×10^{-4}
   (c) 3.5×10^{-4} (d) 1.6×10^{-3}

12. Which indicator will be suitable for the titration of acetic acid *vs* NaOH ?
   (a) Bromocresol green $[pK_{In}=4.7]$

(b) Methyl orange $[pK_{In} = 3.7]$

(c) Phenolphthalein $[pK_{In} = 9.6]$

(d) Chlorophenol $[pK_{In} = 6.1]$

[2004-05]

13. A pair that forms a buffer solution is
(a) NaCl+HCl
(b) BaCl+Ba$(NO_3)_2$
(c) AgCN+KCN
(d) Na_3PO_4+Na_2HPO_4

14. The salt that when added to water will not change its pH is
(a) NaCl (b) Na_2CO_3
(c) NH_4Cl (d) KCN

15. The solubility product of Ag_2CrO_4 is 1.9×10^{-12}. The volume of water in mL that can dissolve 4 mg of Ag_2CrO_4 is about
(a) 1000 mL (b) 150 mL
(c) 500 mL (d) 250 mL

16. In its 0.20 M solution methanoic acid has degree of dissociation 0.032. Hence,its dissociation constant could be
(a) 2.1×10^{-4} (b) 2.1×10^{-2}
(c) 2.6×10^{-8} (d) 1.1×10^{-6}

17. A buffer solution is prepared by mixing 0.050 moles of a weak acid H*A* and 0.20 moles of NaA in a sufficient amount of a water to give 500 mL of solution. K_a for *HA* is 4.5×10^{-4}. The pH of this solution is
(a) 2.17 (b) 1.97
(c) 3.95 (d) 2.74

18. Consider various species generated when H_3PO_4 dissolve in water. Among these, the conjugate acid of HPO_4^{2-} is
(a) $H_2PO_4^-$ (b) H_3PO_4 (c) H_3O^+ (d) PO_4^{3-}

19. If a base has dissociation constant K_b then the value of dissociation constant K_a of its cojugate acid is given by
(a) $\frac{K_w}{K_b}$ (b) $\frac{1}{K_b}$ (c) $\frac{K_w}{K_b}$ (d) $\frac{K_b}{K_w}$

[2003-04]

20. There is a mixture of Cu(II) chloride and Fe(II) sulphate. The best way to separate the metal ions from this mixture in qualitative analysis is by treating it with
(a) Ammonium hydroxide buffer where only Fe(II) hydroxide will be precipitated.
(b) Hydrogen sulphide in mild acidic medium, when only Cu(II) sulphate will be precpitated
(c) Ammonium hydroxide buffer, where only Cu(II)hydroxixde will be precipitated.
(d) Hydrogen sulphide in mild acidic medium, when only Fe(II) sulphide will be precipitated.

21. The following equilibrium exists in saturated solution of NH_4Cl

$$NH_4Cl(s) \rightleftharpoons NH_4^+(ag) + Cl^-(ag)$$

$$\Delta H_{25°C} = 3.5 \text{ kcal mol}^{-1}$$

A change that will shift the equilibrium to the right is
(a) Increase in temperature.
(b) Decrease in temperature
(c) Addition of NH_4OH solution to the reaction mixture
(d) Addition of NH_4Cl crystals to the reaction mixture

22. The pK_a of acetic acid is 4.74, which implies that
(a) At pH of 4.74, the dissociaton of acetic acid maximum.
(b) pH of 1 N acetic acid is 4.74.
(c) At pH 4.74, the dissociation of acetic acid is minimum.
(d) At pH 4.74, half of acetic acid molecules are dissociated in the solution.

23. In titration experiment 50.0 mL of 0.1 N HCl is being titrated against 0.1 N NaOH. The pH of the solution on addition of 49.9 mL of NaOH is approximately
(a) 6.0 (b) 7.0 (c) 3.0 (d) 4.0

24. Sodium hydroxide cannot be used as a primary standard for acid base titration because

(a) The dissolution of sodium hydroxide in water is highly exothermic, hence its concentration change on dissolution.
(b) It is corrosive and react with glass.
(c) Hydroxide cannot be used as primary standards.
(d) It is hygroscopic and also reacts with atmospheric carbon dioxide.

[2002]

25. If H_2S gas is passed in an acidified $ZnSO_4$, the precipitation of ZnS does not take place because
(a) K_{sp} of ZnS is decreased.
(b) K_{sp} of ZnS is not exceeded.
(c) K_{sp} of ZnS is increased
(d) None of the above

26. For the salt of strong acid and weak base, the hydrolysis constant is given by

(a) $K_h = \frac{K_w}{K_a}$ (b) $K_h = \frac{K_w}{K_b}$

(c) $K_h = \sqrt{\frac{K_w}{K_a K_b}}$ (d) $K_h = \frac{K_w}{K_a K_b}$

27. The equilibrium constant for the gaseous reaction $H_2 + Cl_2 \rightleftharpoons 2HCl$ is given by.

(a) $K = \frac{[H_2][Cl_2]}{2[HCl]}$ (b) $K = \frac{[H_2][Cl_2]}{[HCl]^2}$

(c) $K = \frac{2[HCl]}{[H_2][Cl_2]}$ (d) $K = \frac{[HCl]^2}{[H_2][Cl_2]}$

28. The colour change of an acid base indicator is due to the formation of
(a) Quinoid structure
(b) Benzonoid structure
(c) Covalent bond
(d) Ionic structure

29. The Henderson equation for an acidic buffer is

(a) $pH = pK_a + \log\frac{[\text{salt}]}{[\text{acid}]}$

(b) $pH = pK_a + \log\frac{[\text{acid}]}{[\text{salt}]}$

(c) $pH = pK_a + \log[\text{salt}][\text{acid}]$

(d) $pK_w = pK_a + \log\frac{[\text{salt}]}{[\text{acid}]}$

30. pH of circulating blood is maintained around 7.4 by the action of buffer system of
(a) CO_2 / HCO_3^-
(b) $H_2PO_4^- / HPO_4^{2-}$
(c) CH_3COO^- / CH_3COONa
(d) NH_4Cl / NH_4OH

31. Methanol (CH_3OH) is manufactured by the reaction of carbon monoxide with hydrogen in the presence of ZnO/Cr_2O_3 catalyst.

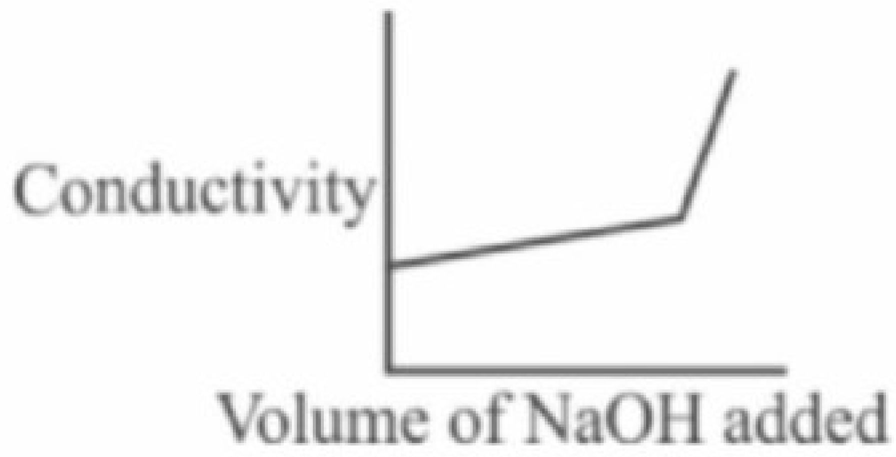
$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH)(g); \quad [\Delta H = -91kJ]$$

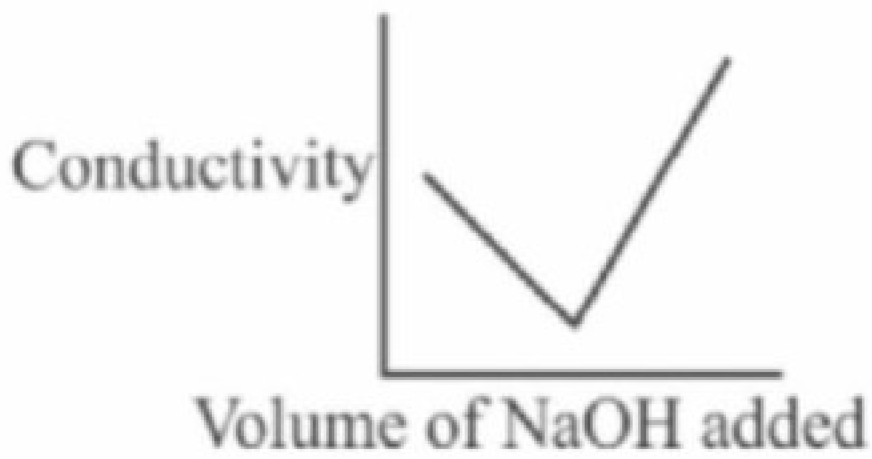
What happen to the amount of methanol when an equilibruim mixture of reactants and products is subjected to rise in temperature?
(a) Amount of methanol will decrease
(b) Amount of methanol will increase.
(c) Amount of methanol will remain same
(d) None of the above

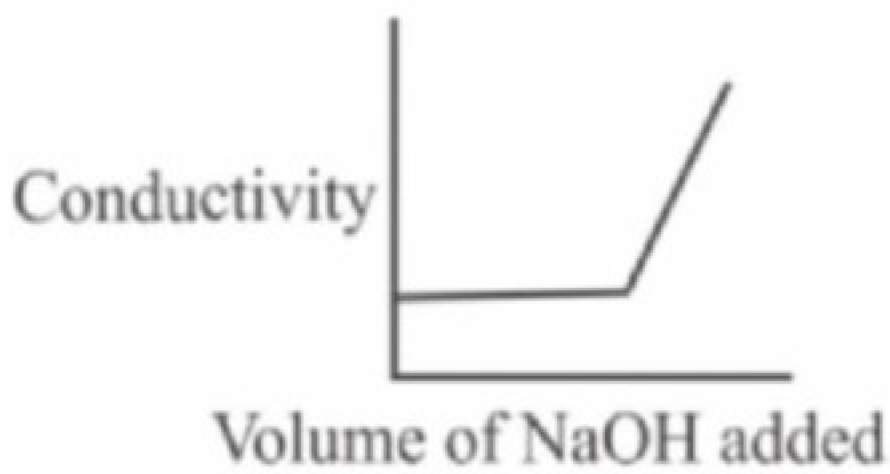
32. When a salt 'X' is dissolved in water at pH =7, the resulting solution becomes alkaline nature. Salt X is made up of
(a) Weak acid and weak base.
(b) Strong acid and strong base.
(c) Strong acid and weak base.
(d) Weak acid and strong base.

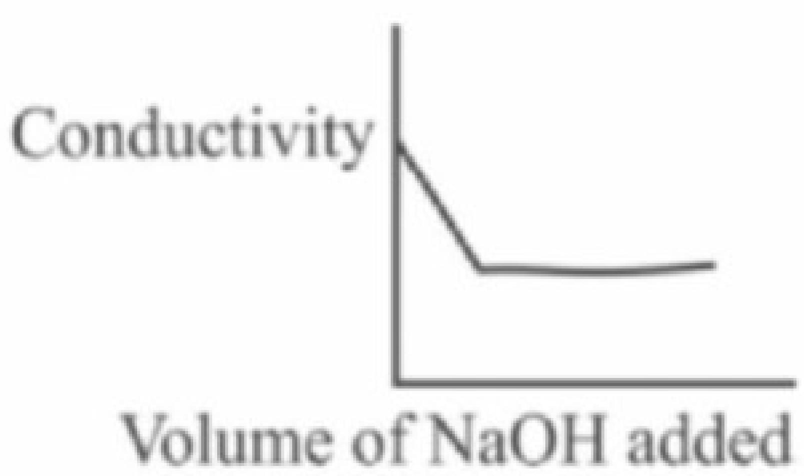
33. The PK_a of aspirin is 3.5. The pH of gastric juice in human stomach while in small intestine, the pH is 8. Aspirin will be
(a) Completely ionised in the small intestine and in the stomach
(b) Unionised in the small intestine and in the stomach
(c) Ionised in the stomach and almost unionised in small intestine.
(d) None of the above

34. In the conductometric titration of CH_3COOH *vs* NaOH, the titration curve obtained will be of the type

(a) 

(b) 

(c) 

(d) 

35. The pH of 10^{-6} M KOH is

(a) 7.0 (b) 6.0 (c) 9.0 (d) 8.0

36. Lead chloride has a solubility product of 1.7×10^{-5} at 300 K. Its solubility will be

(a) 4.123×10^{-3} mol dm^{-3}

(b) 1.62×10^{-2} mol dm^{-3}

(c) 5.1×10^{-3} mol dm^{-3}

(d) 4.123×10^{-6} mol dm

37. The pH of a soft drink is 3.82. Its hydrogen ion concentration in mol dm^{-3} will be

(a) 1.96×10^{-3} (b) 1.5×10^{-4}

(c) 1.96×10^{-1} (d) 1.96×10^{2}

[2001]

38. Pure ammonia is placed in vessel at a temperature where its dissociation is appreciable. At equilibrium

(a) Its degree of dissociation does not change with pressure.

(b) Concentration of ammonia does not change with pressure

(c) Concentration of hydrogen is less than that of nitrogen.

(d) Kp does not change appreciable with pressure.

39. Which of the following does not act as buffer solution?

(a) Boric acid and borax.

(b) sodium acetate and acetic acid.

(c) Sodium acetate and sodium citrate.

(d) Na_3PO_4 and Na_2HPO_4.

40. The equilibrium constant for the reaction $H_2 + Br_2 \rightleftharpoons 2HBr$ is 67.8 at 300 K. The equilibrium constant for the dissociation of HBr is

(a) 67.80 (b) 0.0147

(c) 8.349 (d) 33.90

41. For the gaseous reaction, $C_2H_4 + H_2 \rightleftharpoons C_2H_6$ the equilibrium constant has the units

(a) dm^3 mol^{-1} (b) mol^2 dm^{-3}

(c) mol dm^{-3} (d) dm^2 mol^{-2}

42. The equilibrium constant (K) for this reaction $A + 2B \rightleftharpoons 2C + D$ is

(a) $\dfrac{[2C][D]}{[A][2B]}$ (b) $\dfrac{[C]^2[D]}{[A][2B]}$

(c) $\dfrac{[C]^2[D]}{[A][B]^2}$ (d) $\dfrac{[C][D]}{[A][B]}$

43. The relationsship between equilibrium constant K_P and K_C is

(a) $K_C = K_P(RT)^{\Delta n}$ (b) $K_P = K_C R(T)^{\Delta n}$

(c) $K_P = \dfrac{K_C}{RT^{\Delta n}}$ (d) $K_P = K_C(RT)^{\Delta n}$

ANSWER KEY

1. b	**2.** b	**3.** c	**4.** b	**5.** d
6. c	**7.** a	**8.** d	**9.** b	**10.** c

11. a	**12.** c	**13.** d	**14.** a	**15.** b
16. a	**17.** c	**18.** a	**19.** a	**20.** b
21. a	**22.** d	**23.** d	**24.** d	**25.** b
26.b	**27.** d	**28.** a	**29.** a	**30.** a
31. a	**32.** d	**33.** d	**34.** a	**35.** d
36. b	**37.** b	**38.** d	**39.** c	**40.** b
41. a	**42.** c	**43.** d		

HINTS & SOLUTIONS

1.Sol : At definite temperature, P $p \propto n$. In the forward reaction the no. of moles decreases. So with the increase of pressure reaction will be forwarded.

2.Sol:

$$AlCl_3 + 3H_2O \rightarrow \underset{\text{weak base}}{Al(OH)_3} + \underset{\text{strong acid}}{3HCl}$$

$$Na_2CO_3 + 2H_2O \rightarrow \underset{\text{strong base}}{2NaOH} + \underset{\text{weak acid}}{H_2CO_3}$$

$$NaCl + H_2O \rightarrow \underset{\text{strong base}}{NaOH} + \underset{\text{strong acid}}{HCl}$$

3.Sol: So on hydrolysis of Na_2CO_3; $pH > 7$.

$$Na_2CO_3 + 2H_2O \rightarrow 2NaOH + H_2CO_3$$

$$pH = 10.52$$

4.Sol: $Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$

$$K_{sp} = [Ag^+]^2 [CrO_4^{2-}]$$

$$K_2CrO_4 \rightleftharpoons 2K^+ + CrO_4^{2-}$$

$$AgNO_3 \rightleftharpoons Ag^+ + NO_3^-$$

$$\underset{\text{Weak electrolyte}}{H_2O} \rightleftharpoons H^+ + OH^-$$

$$\underset{\text{strong}}{HNO_3} \rightleftharpoons H^+ + NO_3^-$$

Due to presence of common ions in K_2CrO_4 or $AgNO_3$ solubility decreases. H_2O is a weak electrolyte having no common ion and HNO_3 is a strong electrolyte having no common ion i.e, why solubility will be maximum in HNO_3 soluion.

5.Sol:

$$\underset{25\,ml\,0.01\text{N}}{NaOH} + \underset{50\,ml\,0.01\text{N}}{CH_3COOH} \rightarrow \underset{25\,ml\,0.01}{CH_3COONa} + H_2O$$

$$pH = pK_a + log\frac{[\text{salt}]}{[\text{acid}]}$$

$$= 4.76 + \log\frac{0.25}{0.23}$$

$$= 4.76$$

6.Sol: $PbI_2 \rightleftharpoons Pb^{2+} + 2I^-$

$$K_{sp} = [Pb^{2+}][I^-]^2$$

$\therefore$ Cone of $[I^-] = 2 \times [Pb^{2+}]$

7.Sol: Conceptual

8.Sol: $K_c = \dfrac{[\text{Product}]}{[\text{Reactant}]}$

Therefore when $K_c >> 1$, Product conc. would be much greater than reactant conc. at equilibrium.

9.Sol: $\underset{\text{At equilibrium }(1-\alpha)C}{CH_3COOH} \rightleftharpoons \underset{C\alpha}{CH_3COO^-} + \underset{C\alpha}{H^+}$

$$K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$$

$$K_a = \frac{C\alpha \times C\alpha}{(1-\alpha)}$$

$$\Rightarrow K_a = \alpha^2 C \quad [\text{when } \alpha << 1, 1-\alpha \simeq 1]$$

$$\Rightarrow \alpha^2 C^2 = K_a C$$

$$\Rightarrow \alpha C = (K_a C)^{\frac{1}{2}}$$

$$\Rightarrow [H^+] = (K_a C)^{\frac{1}{2}}$$

$$\Rightarrow -\log[H^+] = -\log(K_a C)^{\frac{1}{2}}$$

$$\Rightarrow pH = -\frac{1}{2}\log K_a - \frac{1}{2}\log C$$

$$\Rightarrow pH = -\frac{1}{2}\log 1.74 \times 10^{-5} - \frac{1}{2}\log 10^{-3}$$

$\Rightarrow \quad pH = 3.88$

10.Sol: $K_w = [H_3O^+][OH^-]$

$\therefore$ Degree of dissociation of water

$$= \frac{10^{-7}\,\text{mol dm}^{-3}}{55.55\,\text{mol dm}^{-3}} = 1.8\times10^{-9}$$

11.Sol: $\underset{S}{Mg(OH)_2} \rightleftharpoons \underset{S}{Mg^{2+}} + \underset{2S}{2OH^-}$

$\therefore \quad K_{Sp} = [Mg^{2+}][OH^-]^2$

$\Rightarrow \quad K_{Sp} = S\times(2S)^2$

$\Rightarrow \quad 4S^3 = K_{Sp}$

$$S = \left(\frac{K_{Sp}}{4}\right)^{\frac{1}{3}}$$

$$\Rightarrow \quad S = \left(\frac{3.4\times10^{-11}}{4}\right)^{\frac{1}{2}}$$

$\Rightarrow \quad S = (8.5)^{\frac{1}{3}}\times10^{-4}$

$\Rightarrow \quad S = 2.026\times10^{-4}$

$\therefore$ Solubility $= 2.026\times58.3\times10^{-4}\, g/\text{lit}$

$= 118\cdot1158\times10^{-4}\, g/lit = 1\cdot2\times10^{-4}\, g/lit$

12.Sol: As after the end point the medium becomes alkaline and suddenly pH increases from 3.34 to 9.70. Only Phenolphthalein is the suitable indicator for this titration.

13.Sol: It is a simple buffer for the mixture of Na_2HPO_4 and Na_3PO_4

14.Sol: It is a salt of strong acid & strong base. So pH remains constant.

15.Sol: $Ag_2CrO_4 \rightleftharpoons 2Ag^+ + CrO_4^{2-}$

$\therefore \quad K_{Sp} = 4S^3$

$$\Rightarrow \quad S = \left(\frac{K_{Sp}}{4}\right)^{\frac{1}{3}}$$

$$\Rightarrow \quad S = \left(\frac{1.9\times10^{-2}}{4}\right)^{\frac{1}{3}}$$

$\Rightarrow \quad S = 0.78\times10^{-4}\, mole/lit = 0.78\times33.2 \times10^{-4}\, g/lit$

$= 258.96\times10^{-4}\, g/lit$

$= 0.0259\, g/lit$

0.0259 g of Ag_2CrO_4 in dissolved in 1000 ml H_2O

0.004 g of Ag_2CrO_4 in dissolved in

$$\frac{1000\times0.004}{0.0259}\, ml\; H_2O$$

$= 154.44\, ml\; H_2O$

16.Sol: $HCOOH \rightleftharpoons HCOO^- + H^+$

$\therefore\; K_a = \alpha^2 C = (0.032)^2\times0.20 = 2.1\times10^{-4}$

17.Sol: Conceptual

18.Sol: Conceptual

19.Sol: $BOH \rightleftharpoons B^+ + OH^-$

$$K_b = \frac{[B^+][OH^-]}{[BOH]}$$

$B^+ + H_2O \rightleftharpoons BOH + H^+$

$$K_a' = \frac{[BOH][H^+]}{[B^+][H_2O]}$$

$$K_a' = \frac{[BOH][OH^-][H^+]}{[B^+][H_2O]\times[OH]}$$

$$\Rightarrow \quad K_a = \frac{[H^+][OH^-]}{\frac{[B^+][OH^-]}{[BOH]}} = \frac{K_w}{K_b}$$

20.Sol: Solubility product of Cu (II) sulphide have lower value than Fe (II) sulphide. So Cu (II) sulphide will be precipitated in presence of mild acidic medium.

21.Sol: With rise of temperature NH_3 will be evolved and reaction will be forwarded.

22.Sol: $$pH = \frac{1}{2}pK_a - \frac{1}{2}\log C$$

$$\Rightarrow \quad 4.74 = \frac{1}{2}\times4.74 - \frac{1}{2}\log C$$

$\Rightarrow \quad C = 10^{-4.74} = 1.8\times10^{-5}$

$$\therefore \underset{At\ equilibrium\ (C_0-1.8\times10^{-5})}{CH_3COOH} \rightleftharpoons \underset{1.8\times10^{-5}}{CH_3COO^-} + \underset{1.8\times10^{-5}}{H^+}$$

$$\therefore K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]} = \frac{1.8\times10^{-5}\times1.8\times10^{-5}}{C_0-1.8\times1.0^{-5}}$$

$$=1.8\times10^{-5}$$

$$\therefore \quad C_0 = 3.6\times10^{-5}$$

23.Sol:

$$\begin{array}{ll} 50.0\ ml\ 0.1N\ HCl & \equiv 5.000\ ml \quad 1\ N\ HCl \\ 49.9\ ml\ 0.1N\ NaOH & \equiv 4.999\ ml \quad 1\ N\ NaOH \\ \hline 99.9\ ml\ xN\ mixture & \equiv 0.001\ ml \quad 1N\ HCl \end{array}$$

$$\therefore \quad x = \frac{0.001}{99.9} = 10^{-4}\ \text{N}$$

$$\therefore \quad pH = -\log10^{-4} = 4$$

24.Sol: NaOH is hygroscopic and reacts with aerial CO_2

25.Sol: Solubility product ZnS is very high . So in presence of H^+ ion decreases the S^{2-} ion concentration.

26.Sol: $B^+ + H_2O \rightarrow BOH + H^+$

(Cationic salt hydrolysis)

$$K_h = \frac{[BOH][OH^-][H^+]}{[B^+][OH^-]} = \frac{[H^+][OH^-]}{\frac{[B^+][OH^-]}{[BOH]}} = \frac{K_w}{K_b}$$

27.Sol: $H_2(g) + Cl_2(g) \rightleftharpoons 2HCl$

$$\therefore \quad K = \frac{[HCl]^2}{[H_2][Cl_2]}$$

28.Sol: $\underset{colourless}{HPh} \rightleftharpoons H^+ + \underset{pink}{Ph^-}\ (ionic\ form)$

29.Sol: Conceptual

30.Sol: Conceptual

31.Sol:

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)[\Delta H = -91KJ]$$

Forward reaction is exothermic. So rise of temperature the reaction will be backwarded.

32.Sol: The salt is made of weak acid strong base.

33.Sol: Aspirin is acidic in nature. So it will not be ionised in stomach but it will be ionised in small intestine in alkaline medium.

34.Sol:

$$\underset{weak\ acid}{CH_3COOH} + \underset{strong\ acid}{NaOH} \rightleftharpoons \underset{strongelectrolyte}{CH_3COO^-Na^+} + H_2O$$

35.Sol:

$$pOH = -\log(10^{-6}+10^{-7}) = -\log10^{-6}\left(\frac{11}{10}\right)$$

$$= 6 - \log\frac{11}{10} = 6 - 0.041 = 5.959$$

$$\therefore \quad pH = 14 - 5.9\,59 \simeq 8$$

36.Sol: $\underset{S}{PbCl_2} \rightleftharpoons \underset{S}{Pb^{2+}} + \underset{2S}{2Cl^-}$

$$K_{Sp} = [Pb^{2+}][Cl^-]^2$$

$$\Rightarrow 1.7\times10^{-5} = 4S^3$$

$$\Rightarrow S = \left(\frac{1.7}{4}\times10^{-5}\right)^{\frac{1}{3}} = (4.25\times10^{-6})^{\frac{1}{3}}$$

$$= 1.61\times10^{-2}$$

37.Sol: $pH = -\log_{10}[H^+]$

$$[H^+] = 10^{-3.82} = 1.5\times10^{-4}$$

38.Sol: Conceptual

39.Sol: Sodium acetate and sodium nitrate both are salt of weak acid.

40.Sol: $H_2 + Br_2 \rightleftharpoons 2HBr$

$$K_c = \frac{[HBr]^2}{[H]_2[Br]^2} = \frac{1}{67.8}$$

$$K_c' = \frac{1}{\frac{[H_2][BH_2]}{[HBr]^2}} = \frac{1}{67.8}$$

$$= 0.0147$$

41.Sol: Conceptual

42.Sol: $A + 2B \rightleftharpoons 2C + D$

$$K = \frac{[C]^2[D]}{[A][B]^2}$$

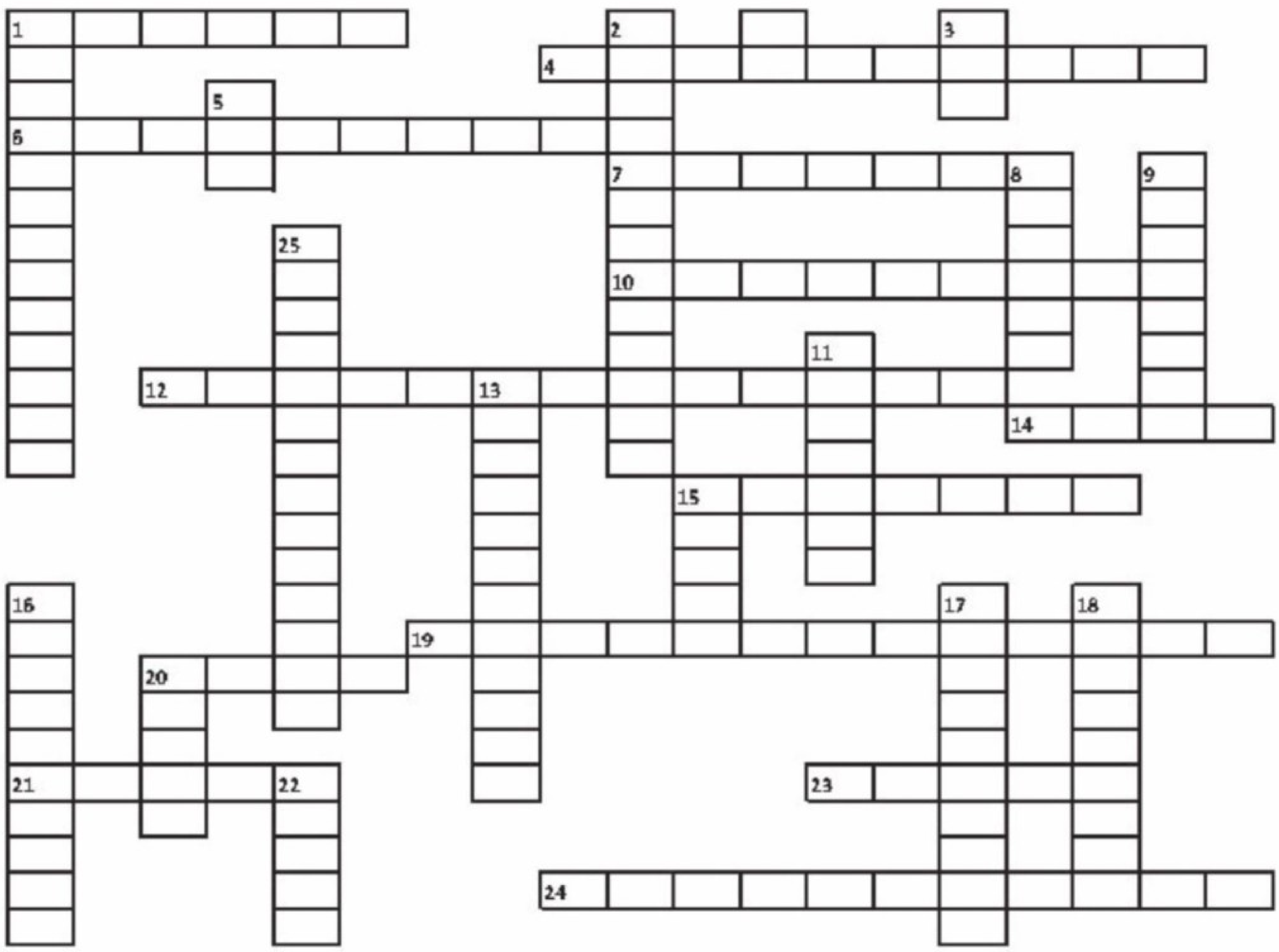
43.Sol: Conceptual

CROSS WORD PUZZLE

ORGANIC (5)

By: **Arup Kumar Chakravorthi** (Kolkata)

I.



Across :-

1. Isopropylbenzene (6)

4. When S_2Cl_2 reacts with ethene a highly poisonous gas is formed. (10)

6. The chemical which either kill or prevent the growth of micro-organisms. (10)

7. Isomers having different on C_1 atom (7)

10. A dipolar ion derived from amino acid (9)

12. Indole (1, 2, 3- trione) is used for test. (13)

14. The protein portion of haemoglobin. (4)

15. A simple aldohexose sugar which is the isomer of glucose (7)

19. Aniline can be converted to fluoro benzene by the named reaction (13)

21. Aminophenol (5)

24. Non superimposable mirror images (11)

Down :-

1. An alternative name of potassium hydrogen tartrate (13)

2. A process by which cross link is made between the elastomer with sulphur (13)

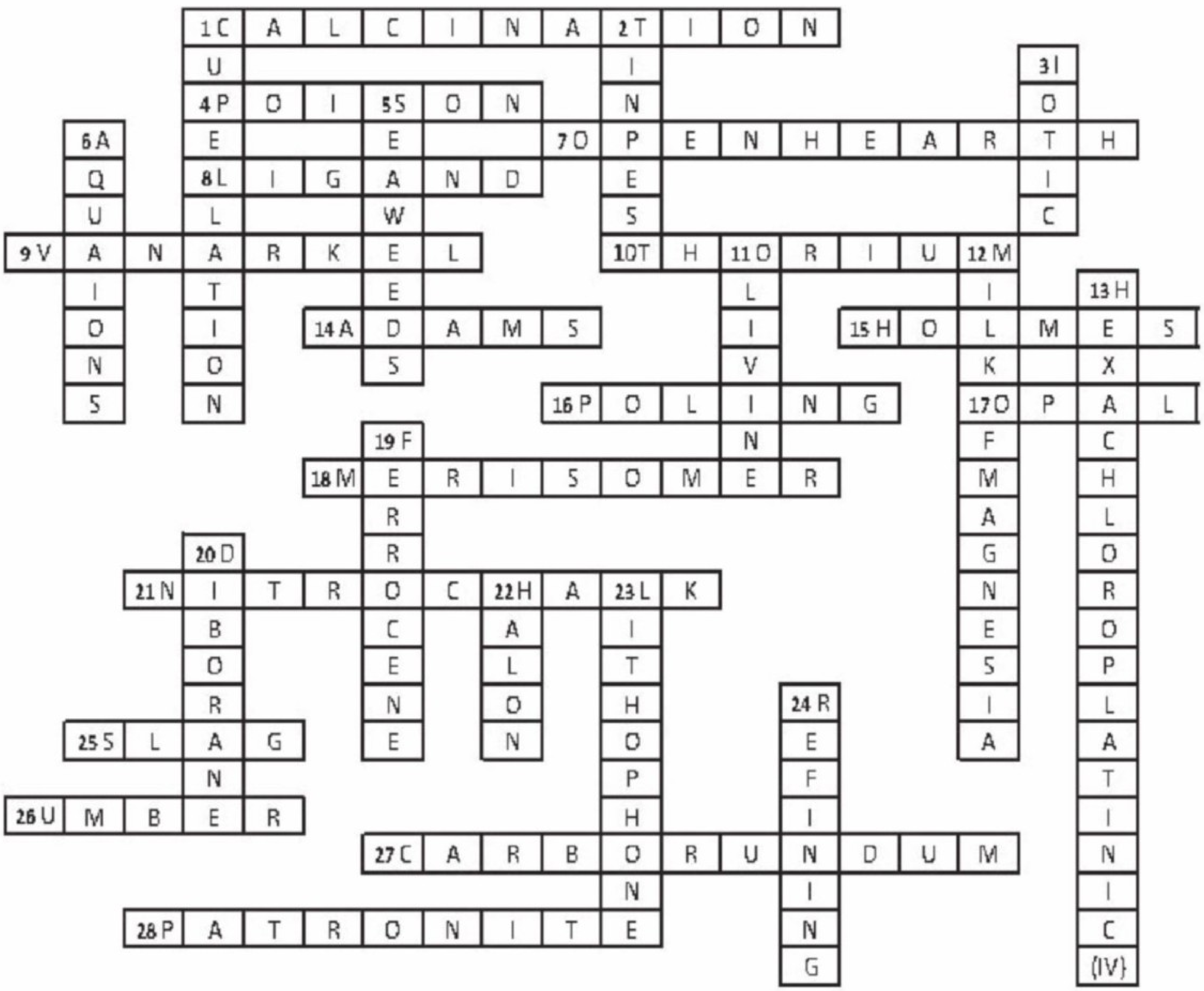
3. Cyclonite is also known as ....

5. Mixture of glacial acetic acid and ICl which is used as highly explosive is called ....(3) reagent

8. The reagent is used to identify a carbonyl compound. (6)
9. The rule which is used to denote the structure of α-amino acids. (8)
12. Linear product by the reaction with phenol and formaldehyde (7)
13. Alternation of structure, except primary. (11)
15. The general test for carbohydrates (8)
17. The process d, *l* mixtures is seperated into d and *l* forms with the help of chiral catalyst (10)
18. A crystalline colour trisaccharide formed in beet sugar (9)
20. To prepare even number of carbon containing alkane compound .... (5) reaction is useful
22. Mixtures of cresol and water in the ratio 1:1.
25. Ester hydrolysis in basic medium (14)

Solution to the above puzzle will be published in the November month issue.

PUZZLE SOLUTION: SEPTEMBER MONTH ISSUE



CHEMIS TRICKS

By: A.N.S. SANKARA RAO (Hyderabad)

n-FACTOR

One can solve problems based on stoichiometry and solutions (especially normality linked) easily by knowing simple chemistricks, logic of n-factor (also called as valency factor). One must know the type & extent of the reaction for calculating n-factor of any reactant in any reaction.

n-factor for Acids / Bases / Salts:

ACIDS: According to Arrhenius theory, acid is the substance that furnishes H$^+$ ion (s) in water. n-factor is nothing but basicity (no.of H$^+$ ions furnished per one molecule of the acid). n-factor depends upon the extent of the reaction that undergoes. It need not be equal to its basicity.

$$HNO_3 \rightarrow H^+ + NO_3^- \qquad (n=1)$$

$$HCl \rightarrow H^+ + Cl^- \qquad (n=1)$$

$$CH_3COOH \rightarrow H^+ + CH_3COO^- \qquad (n=1)$$

$$H_2SO_4 \rightarrow H^+ + HSO_4^- \qquad (n=1)$$

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{-2} \qquad (n=2)$$

$$H_3PO_2 \rightarrow H^+ + H_2PO_2^- \qquad (n=1)$$

$$H_3PO_3 \rightarrow H^+ + H_2PO_3^- \qquad (n=1)$$

$$H_3PO_3 \rightarrow 2H^+ + HPO_3^{-2} \qquad (n=2)$$

$$H_3PO_4 \rightarrow H^+ + H_2PO_4^- \qquad (n=1)$$

$$H_3PO_4 \rightarrow 2H^+ + HPO_4^{-2} \qquad (n=2)$$

$$H_3PO_4 \rightarrow 3H^+ + PO_4^{-3} \qquad (n=3)$$

$$H_2SO_3 \rightarrow H^+ + HSO_3^- \qquad (n=1)$$

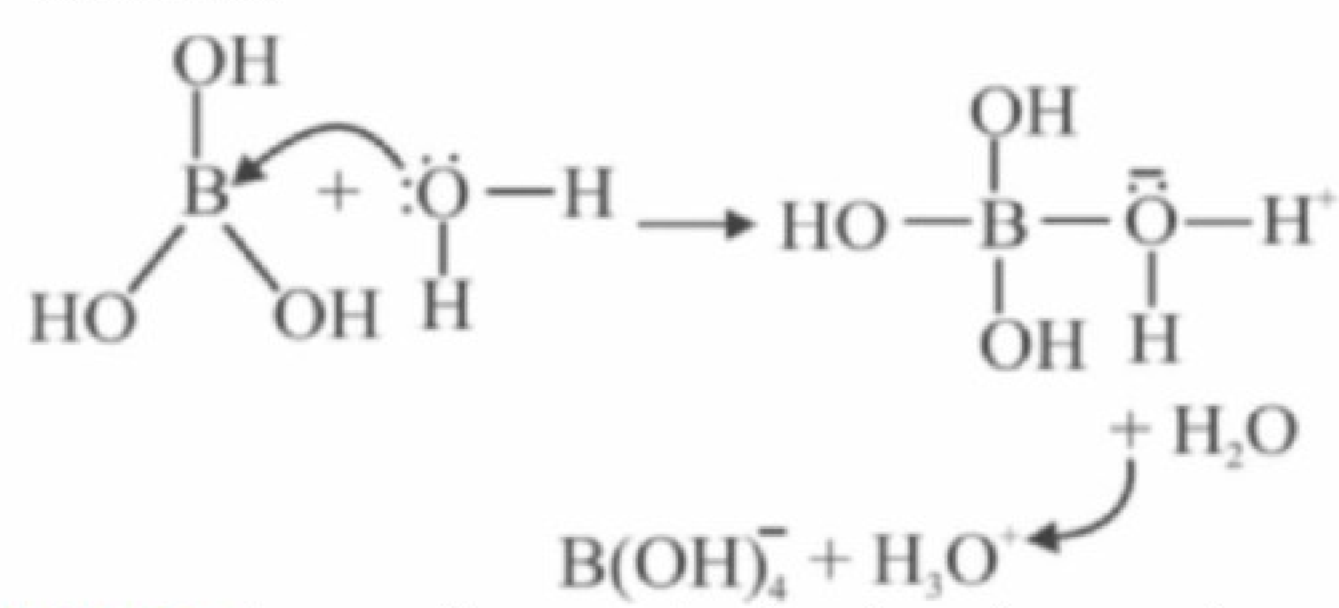
$$H_2SO_3 \rightarrow 2H^+ + SO_3^{-2} \qquad (n=1)$$

$$H_2CO_3 \rightarrow H^+ + HCO_3^- \qquad (n=1)$$

$$H_2CO_3 \rightarrow 2H^+ + CO_3^{-2} \qquad (n=2)$$

$$H_3BO_3 \rightarrow \left[B(OH)_4\right]^- + H_3O^+ \qquad (n=1)$$

Here H_3BO_3 is electron deficient, acts as Lewis acid, it gives one H$^+$ ion in water as follows.



BASES: According to Arrhenius theory, base is the substance that furnishes OH$^-$ ion (s) in water. Where n-factor is nothing but acidity (no. of OH$^-$ ions furnished per one molecule of the base). n-factor of a base need not be equal to its acidity. It depends up on the extent of the reaction

$$NaOH \rightarrow Na^+ + OH^- \qquad (n=1)$$

$$Ca(OH)_2 \rightarrow [Ca(OH)]^+ + OH^- \qquad (n=1)$$

$$Ca(OH)_2 \rightarrow Ca^{+2} + 2\,OH^- \qquad (n=2)$$

n-factor of $Al(OH)_3$ may be 1 or 2 or 3 depends upon no.of OH$^-$ ions released.

SALTS: Where n-factor of salt is equal to total charge on cations or anions. Present in the salt.

$$2Na_3PO_4 + 3BaCl_2 \rightarrow 6NaCl + Ba_3(PO_4)_2$$

where 3 moles of Na$^+$ ions are present in 1 mole of Na_3PO_4, hence n-factor of Na_3PO_4 is 3 (total charge on 3Na$^+$ ions).

$NaCl \quad (n=1)$

$MgCl_2 \quad (n=2)$

$AlCl_3 \quad (n=3)$

$Al\,N \quad (n=3)$

$Al_2(SO_4)_3 \quad (n=6)$

$B_2O_3 \quad (n=6)$

$$\underset{2(+1)}{K_2}\,SO_4 \cdot \underset{+\ 2(+3)=8}{Al_2}\,(SO_4)_3 \cdot 24H_2O \quad (n=8)$$

$$\underset{+2}{Fe}\,SO_4 \cdot \underset{+\ 2(+1)=4}{(NH_4)_2}\,SO_4 \cdot 6H_2O \quad (n=4)$$

$$\underset{(+1)}{KCl} \cdot \underset{+(+2)=3}{Mg}Cl_2 \cdot 6H_2O \quad (n=3)$$

$CuSO_4 \cdot 5H_2O \quad (n=2)$

$Cr_2O_7^{-2} \quad (n=7)$

$K_4[Fe(CN)_6] \quad (n=4)$

The reaction in which reduction and oxidation (**red**uction + **ox**idation = **redox**) takes place is known as "**redox**" reaction. Where n-factor depends upon change in oxidation state of the species (to be studied).

Type - I

n-factor = total change in O.S. (oxidation state) per molecule

Chemistrick for $KMnO_4$: B N A 1 3 5

In basic medium

$$\underset{(+7)}{KMnO_4} \xrightarrow{OH^-} \underset{(+6)}{MnO_4^{-2}} \quad \therefore\ n = 7-6 = 1$$

In neutral (dilute alkali) medium

$$\underset{(+7)}{KMnO_4} \xrightarrow{H_2O} \underset{(+4)}{MnO_2} \quad \therefore\ n = 7-4 = 3$$

In acid medium

$$\underset{(+7)}{KMnO_4} \xrightarrow{H^+} \underset{(+2)}{MnSO_4} \quad \therefore\ n = 7-2 = 5$$

OTHERS:

$$\underset{(+6)}{Cr_2O_7^{-2}} \xrightarrow{H^+} \underset{(+3)}{2Cr^{+3}} \quad n = 2(6-3) = 6$$

$$\underset{(+3)}{C_2O_4^{-2}} \longrightarrow \underset{(+4)}{2CO_2} \quad n = 2(4-3) = 2$$

$$\underset{(+2)}{Fe^{+2}} \longrightarrow \underset{(+3)}{Fe^{+3}} \quad n = 3-2 = 1$$

$$\underset{(0)}{I_2} \longrightarrow \underset{(-1)}{2I^-} \quad n = 2[0-(-1)] = 2$$

$$\underset{(+2)}{S_2O_3^{-2}} \xrightarrow{OH^-} \underset{(+6)}{SO_4^{-2}} \quad n = 2(6-2) = 8$$

$$\underset{(+1)}{ClO^-} \longrightarrow \underset{(-1)}{Cl^-} \quad n = 1-(-1) = 2$$

$$\underset{(+5)}{IO_3^-} \longrightarrow \underset{(-1)}{I^-} \quad n = 5-(-1) = 6$$

$$\underset{(+5)}{NO_3^-} \longrightarrow \underset{(+4)}{NO_2} \quad n = 5-4 = 1$$

$$\underset{(+5)}{NO_3^-} \longrightarrow \underset{(+3)}{NO_2^-} \quad n = 5-3 = 2$$

$$\underset{(+5)}{NO_3^-} \longrightarrow \underset{(+2)}{NO} \quad n = 5-2 = 3$$

$$\underset{(+5)}{NO_3^-} \longrightarrow \underset{(+1)}{N_2O} \quad n = 5-1 = 4$$

$$Sn^{+2} \longrightarrow Sn^{+4} \quad n = 4-2 = 2$$

$$S^{-2} \longrightarrow S \quad n = 0-(-2) = 2$$

$$\underset{(0)}{6Br_2} \longrightarrow \underset{(-1)}{10Br^-} + \underset{(+5)}{2Br^{+5}}$$

$$n - \text{factor of Br} = \frac{10[0-(-1)] + 2[5-0]}{12}$$

$$= \frac{10+10}{12} = \frac{20}{12} = \frac{5}{3}$$

Here out of 12 Br atoms $(6 \times Br_2 = 12Br)$, 10 Br atoms are changed into Br^- and 2 Br atoms changed into Br^{+5} ions. Hence we calculate n factor of single Br atom.

$$\text{n - factor of } Br^- = \frac{10[0-(-1)]}{10} = \frac{10}{10} = 1$$

$$\text{n - factor of } Br^{+5} = \frac{2(5-0)}{2} = \frac{10}{2} = 5$$

Chemistrick:

n - factor of Mono atomic ion = Magnitude of the charge of the ion

Type-II

n - factor

$$= \frac{\text{total change in O.S}}{\text{total no. of atoms undergoing oxidation or reduction}}$$

We use this formula for disproportionation reactions. We could able to calculate n-factor only from the balanced reaction.

$$3\underset{(+7)}{MnO_4^-} \longrightarrow 2\underset{(+2)}{Mn^{+2}} + \underset{(+6)}{Mn^{+6}}$$

total decrease in O.S. of

$$Mn = 2(7-2)+1(7-6) = 10+1 = 11$$

This change is applicable for $3MnO_4^-$ ions.

$$\therefore\ n-\text{factor} = \frac{11}{3}$$

Type-III

O.S of one atom of the salt changes in one product does not change in other products.

$$K_2Cr_2O_7 + 14H\underset{(-1)}{Cl} \rightarrow 2K\underset{(-1)}{Cl} + 2Cr\underset{(-1)}{Cl_3} + 3\underset{(0)}{Cl_2} + 7H_2O$$

Out of 14 Cl^- ions O.S. changed for 6Cl atoms to zero O.S., remaining $2Cl^-$ (of 2KCl) and $6Cl^-$ (of $2CrCl_3$) does not change.

So $n-\text{factor of HCl} = \frac{6[0-(-1)]}{14} = \frac{6}{14} = \frac{3}{7}$

$$n-\text{factor of } K_2Cr_2O_7 = \frac{2(6-3)}{1} = 6$$

Type-IV

O.S. of 2 or more atoms of the salt undergo either oxidation or reduction.

n-factor = total change of O.S. in oxidation & reduction per 1 mole

$$\underset{(+2)}{Fe}\ \underset{(+3)}{C_2}O_4 \longrightarrow \underset{(+3)}{Fe^{+3}} + 2\underset{(+4)}{CO_2}$$

n-factor of FeC_2O_4

$$= \frac{1(3-2)+2(4-3)}{1}$$

$$= \frac{1+2}{1} = 3$$

Type-V

O.S. of one atom of the salt increases (oxidation) where as other atom of the salt decreases (reduction). We consider n-factor of salt either by considering oxidation or by reduction.

$$(\underset{(-3)}{NH_4})_2\underset{(+6)}{Cr_2}O_7 \longrightarrow \underset{(0)}{N_2} + \underset{(+3)}{Cr_2}O_3$$

oxidation

reduction

❍ Considering Oxidation:

$$n-\text{factor} = 2[0-(-3)] = 6$$

❍ Considering Reduction:

$$n-\text{factor} = 2(6-3) = 6$$

$$2H_2\underset{-1}{O_2} \longrightarrow 2H_2\underset{-2}{O} + \underset{0}{O_2}$$

reduction

oxidation

❍ Considering Oxidation:

$$n-\text{factor} = 2[0-(-1)] = 2$$

Considering Reduction:

$$n-\text{factor} = 2[-1-(-2)] = 2$$

If you solve this question same as type II

$$n-\text{factor} = \frac{2+2}{2} = 2$$

(**Note:** Where denominator is equal to number of H_2O_2 molecules)

PRECIPITATION REACTIONS:

$$\underset{(+2)}{Pb}(\underset{(-1)}{NO_3})_2 + 2\underset{(+1)}{K}\ \underset{(-1)}{I} \rightarrow \underset{(+2)}{Pb}\ \underset{(-1)}{I_2} + 2\underset{(+1)}{K}\ \underset{(-1)}{NO_3}$$

Here O.S. of Pb, I, NO_3, remains unchanged. Students may misunderstand that n-factor of them is equal to zero. In this type of reactions n-factor of the salt is either sum of total O.S. of either cation or anion.

n-factor of $Pb(NO_3)_2 = (+2)\times 1 = 2$

n-factor of $KI = (+1)\times 1 = 1$

Worked example: In redox reaction, $Ba(MnO_4)_2$ oxidises $K_4[Fe(CN)_6]$ into K^+, Fe^{+3}, CO_3^{-2} and NO_3^- ions in acidic medium, where $Ba(MnO_4)_2$ itself reduces into Mn^{+2}, then how many moles of $Ba(MnO_4)_2$ will react with 1 mole of $K_4[Fe(CN)_6]$.

$$K_4[\underset{(+2)}{Fe}(\underset{(+4)}{C}\ \underset{(-5)}{N})_6] \longrightarrow 4\underset{(+1)}{K^+} + \underset{(+3)}{Fe^{+3}} + 6\underset{(+4)}{C}O_3^{-2} + \underset{(+5)}{N}O_3^-$$

n-factor of the complex

$$= \frac{1(3-2)+6[5-(-5)]}{1} = 61$$